STATUS - RICE BRAN STABILIZATION

DAVID A. FELLERS

1/16/87

United States Department of Agriculture
Office of International Cooperation and Development

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I. STATUS IN THE PHILIPPINES

A. Memorandom of Understanding (MOU)[1]

A MOU was signed by the National Food Authority (NFA) of the Philippines and USAID/MANILA 4/4/84 to set forth the responsibilities of NFA and USAID covering the stabilization of rice bran and the recovery and marketing of edible rice bran oil. USAID's major inputs were the design and supply of a rice bran stabilization plant (extrusion based) and up to one man-year of short term technical assistance. NFA's responsibilities were to supply a suitable building for the stabilization unit; operate the unit for at least one year suplying labor, utilities, and rice bran; arrange for oil extraction and refining; market rice bran oil and defatted stabilized rice bran; and, provide operational and financial records to document the technical and economic aspects of rice bran stabilization and oil extraction, refining, and marketing.

B. Establishment of The Rice Bran Stabilization (RBS) Plant

Rice Bran Stabilization (RBS) equipment costing US $52,000[2] was installed at a cost of $7,500 at the NFA Grain Complex at Cabanatuan, Luzon in January 1985. Transportation costs for the equipment are not included. The installation was made in the same building housing a 10 MT palay/hour Satake rice mill. Rice bran is pneumatically conveyed from the Satake to a surge tank just before a Model 2160 Brady extruder. Extruded rice bran is deposited in a closed belt conveyor (holds bran at close to 212°F for 2.5 minutes) which transports it to a rotating cylindric cooler fitted with an air blower. Cooled stabilized rice bran (SRB) is deposited in a packaging surge tank. RBS operations began 2/12/85.

C. Rice Bran Stabilization Start-up Operations 2/12/85 - 5/31/85

1. Rice Bran Supply. The supply of rice bran for operations during this period was the NFA Satake rice mill. Compositional analyses showed lipid content varied from 9.7 to 15.2%; crude fiber from 3.1 to 7.1%; and, starch from 26.0 to 43.3%. The Satake produced 700 to 900 KG rice bran per hour compared to the extruder capacity of 450 KG/hour. Eighteen percent of a coarse fraction (on a 20 mesh screen) could be removed from the raw bran and consisted of broken rice, rice germs and fragments thereof, and hulls. The lipid content of the coarse fraction was 4.0% lower than the whole bran. Removal of the coarse fraction results in only a slightly higher lipid content in the residual fine fraction. (Later work showed a tendency toward more uniform extruder operation and more uniform flakes when the coarse fraction was removed from the raw rice bran before extrusion.)

2. Rice Bran Stabilization (RBS) Costs[3, 4]. Based on a desired two 8-hour shifts per day, Monday through Friday schedule, operations achieved 16% of capacity. A total of 92 MT of stabilized rice bran (SRB) was produced during this period. Direct labor cost per KG SRB produce were 0.405 pesos (2.025¢); production overhead costs per KG SRB were 0.353 pesos (1.765¢). Assuming extraction would recover 10% of SRB as crude rice bran oil and refining losses would be 50%, RBS costs per gallon of refined rice bran oil would be 51.5 peso ($2.57). The costs do not include cost of rice bran, credit for by-products, transportation costs, or amortization of the plant. Projecting these results to operations at 100% capacity and with the solving of the severe extruder wear problem, direct labor costs would be 0.149 pesos (0.745¢) per KG SRB and production overhead costs 0.169 pesos (0.845¢) per KG SRB. RBS costs per gallon of refined edible rice bran oil would be 21.6 pesos (US $1.08). During this time period, corn and soy oils were retailing

at about $8.30 and refined rice bran oil at $6.60/gallon.

3. Severe Extruder Wear Problem Identified. The Brady extruder with new rotor showed consistent output for the first 40 or 50 hours of operation. After such a length of operation, the working temperature of 250°F began to fluctuate noticeably thereby requiring frequent adjustments on the cone outlet. The quality and uniformity of the extrudate flakes also deteriorated. After 80 to 90 hours of operation, the first, second, and third flights of the rotor were so badly worn that extrusion was no longer possible and rotor and cone/cup had to be replaced. The wear problem just described was observed to be the same on a second new rotor. A wear resistant chrome coated rotor lasted a little longer (100 hours) but cannot be considered acceptable. Rotor life of up to 2,000 hours was expected based on work by WRRC/USDA at PIRMI, Woodland, CA[5]. The V-belt drive system on the Philippine extruder was not present on the PIRMI unit and is suspected of causing a malalignment of the rotor thus contributing to the excessive wear observed. A direct drive system was designed by Colorado State University and ordered to replace the V-belt drive system. The problem was reported to Brady International Corporation who has subsequently converted all extruders to direct drive units.

The significance of the wear problem on cost was studied[6]. At 80 hours wear out, rotor and cone/cup replacement added $0.93/gallon rice bran oil while 500 hour wear out adds $0.15/gallon.

4. Inadequate Stability of Stabilized Rice Bran (SRB). Initial extrusion conditions of 250°F (surface thermometer on top of barrel at die end) with 1.76% added water, while producing a high quality chip, proved to be grossly inadequate to stabilize the rice bran and after 2-months storage,

at about $8.20 and refined rice bran oil at [illegible]/gallon.

3. Severe Extruder Wear Problem Encountered. The Brady extruder with [illegible] rotor showed consistent output for the first 200 hours of [illegible] operation. After such a length of operation, the [illegible] fluctuate noticeably thereby causing [illegible] output. The [illegible] and [illegible] deteriorated [illegible]

[illegible]

converted [illegible] direct drive gears.

The significance of the wear problem was not studied. At 200 hour wear out, rotor and cone replacement added $0.03/gallon [illegible] while 500 hour wear out adds $0.15/gallon.

4. Inadequate Stability of Stabilized Rice Bran (SRB). [illegible] sion conditions of 250°F (surface thermometer on top of barrel at die end) with 1.75% added water, while producing a high quality SRB, proved to be grossly inadequate to stabilize the rice bran and after 2-months storage

free fatty acids (FFA) of the SRB were as high as 46%. On 4/18/85, the extrusion temperature was increased to 270°F. SRB made during the period was unsuitable for oil extraction.

D. Effect of Extrusion Temperature on Stability; 6/11/85 Experiment[7].

Rice bran was extruded on the V-belt drive Brady extruder at 5°F increments from 250 to 280°F and with 1% added water. Temperature was determined using the surface thermometer on the barrel. Following extrusion, the product entered a covered conveyor where temperature was maintained at about 210°F for 2.5 minutes before cooling in a rotating cylinder with forced ambient air.

The products were tested for residual catalase activity (indicator of residual lipase) by release of oxygen (formation of foam) from hydrogen peroxide. Degree of foam formation was high at 250, 255, and 260°F, declined at 265°F, declined further at 270°F and then remained constant or declined slightly at 275 and 280°F. Based on this experiment, it was recommended to process all future rice bran at 280°F until such time that a lower temperature could be shown effective. Temperatures greater than 280°F are hard to obtain with rice bran and result in erratic extruder operation (V-belt drive).

Two 35 KG sacks of product at each processing temperature were place in the warehouse normally used for storage of SRB. Free fatty acids (FFA) were measured at 0, 2, 4, 6, 8, and 13 weeks. Results showed that none of the samples were stable. The highest temperature (280°F) sample started at 2.9% FFA and progressed to 3.0,3.6, 5.6, 6.1, and 8.8% at 0, 2, 4, 6, 8, and 13 weeks respectively. This led NFA to believe that SRB could not be stored

free fatty acids [illegible] ... [illegible] (A/B), the extraction temperature [illegible] ... [illegible] unsuitable [illegible]

D. Effect [illegible] ... [illegible]

[illegible]

[illegible]

measured at 0, 2, 4, [illegible], and [illegible] weeks [illegible] samples were stable. The highest temperature (290°F) [illegible] FFA and progressed to 3.0, 3.5, 4.6, 6.1, [illegible] at 0, 2, 4, [illegible] weeks respectively. This led us to believe that 290 [illegible]

more than three months before extraction if FFA's are to be kept sufficiently low to allow for economic oil recovery. NFA's plan was to process SRB for two months and then ship it to the extractor to insure that extraction occurs within 3-months.

These results are inconsistent with work of WRRC/USDA at PIRMI, Woodland, California where rice bran with 2% added water extruded at 270°F (132°C) showed no increase in FFA's over 19 weeks in storage. This suggests there may be a relationship between the severe extruder wear problem being encountered with the V-belt drive and incomplete stabilization. It is hypothesized that rotor malalignment caused by the V-belt drive results in product on one side of the rotor to be thicker and thus not uniformly heated. The problem would be exaggerated as wear on the rotor increased.

E. <u>Direct Drive Installed on Brady Extruder 9/27/85</u>.

A July 1985 review of possible causes of the severe extruder wear identified the V-belt drive design as a likely causative agent. The driven pulley is attached to the rotor near the bearings. The two opposing thrust bearings near the pulley are not far enough apart to prevent the effect of pull and tension of the belts on the rotor, thus, the rotor is held at an angle within the barrel or biased to one side at the cone/cup interface. This tension coupled with pull to transmit power created an eccentricity between the cup and cone which is believed to amplify wear and create non-uniformity of flakes and of flake heating (stabilization). The new direct drive with a 900 rpm 75 horsepower electric motor was installed 9/27/85. The extruder was operated so that the extrudate discharge could be observed. Results showed that product extruded uniformly from the die and the extrudate itself was more uniform in thickness and flake size. In addition, it

was observed that the direct drive system allowed the addition of more water to the rice bran which could enhance lipase inactivation and thus achieve better stability.

F. Rice Bran Stabilization Operations 9/27/85 - 1/16/87.

In early October 1985, NFA authorized a budget of 1.3 million pesos (US $70,000) for the project. The budget was intended to cover purchase of 200 - 300 MT rice bran from several private rice millers over a 3-month period, stabilization of the bran, and one oil extraction/refining cycle. (NFA lacked sufficient stocks of palay for internal production of rice bran.) From 10/11 - 10/16/85, NFA purchased 5.5 MT rice bran and stabilized it using 280°F and 2.6% water addition. The Plant Manager noted, "The nature of the output products coming out of the extruder (direct drive system) have been quite impressive and observed to have met the intended product (flake) size and quality".

On 10/19/85, Cabanatuan was struck by Typhoon Saling causing severe damage and protracted loss of electrical power. The stabilizer was unable to operate and operations did not recommence until mid-February 1986. At that time, 25 MT of private mill rice bran was stabilized at the rate of 2 to 3 MT per day until a spending freeze was imposed by NFA on all its units on March 10, 1986. The spending freeze arose as a result of the national election and installation of the new Aquino Government and continues to this day for the rice bran stabilization project. Furthermore, NFA has undergone a protracted reorganization during 1986. The Production Services Directorate (PSD), which managed the rice bran stabilization project, has been disbanded and it is not known if another NFA unit or other organization has been given responsibility for the project.

was observed that the direct drive system, without the addition of more space to the fire brush which [illegible] better stability.

F. [illegible]

[illegible]

on March 10, 1986. [illegible]

[illegible]

Stability of the SRB produced on the direct drive Brady in October 1985 and February 1986 is not known. Therefore, it is unknown if the direct drive installation has enhanced stability.

About 30 MT of SRB has been produced since adding the direct drive system to the extruder. This has been an insufficient quantity to determine if the severe extruder wear problem has been solved. Comments from NFA suggest significant improvement but actual measurements are lacking.

G. Other Information, The Philippines.

1. Rice Bran Fat Content. NFA has 10 MT palay/hour Satake rice mills at several locations throughout the Philippines. Samples of rice bran have been analyzed for fat content from four of them and the results are shown in Table I.

TABLE I.

NFA Mill Location	Year	No. of Samples	% Fat Content, asis basis Range	Average
1. General Santos	1983	2	15.0-15.1	15.1
2. Iloilo	1983	2	12.8-12.9	12.9
3. Tarlac, Luzon	1985	2	11.4-11.8	11.6
4. Cabanatuan, Luzon	1984	14	9.7-15.2	12.5
5. Cabanatuan, Luzon	1985	6	11.5-13.9	12.6
TOTALS/AVE.		26	9.7-15.2	12.7

Private millers most commonly use 1-MT palay/hour cono-type mills (various manufacturers) that produce three fractions of darak (rice bran): DKC, DKB, and DKA. DKC is the screenings obtained from scalping brown rice after dehulling and aspiration, DKB is rice bran removed at the first polishing stone and that passes through the screen surrounding the stone.

TABLE II

Private Rice Milling Company; Cono-type	Location	Year	Type of Bran	%Fat Content; as is
1. Trinidad	Cabanatuan, Luzon	1985	DKB + DKA	14.6, 14.2, 17.8, 19.
2. Avilla	Cabanatuan	1985	DKA	19.0
Avilla	"	1985	DKB	19.5
3. Bernardo	Cabanatuan, Luzon	1985	DKA	17.1
"	" "	1985	DKB	15.6
"	" "	1985	Mata Mata 1st	20.4
"	" "	1985	Mata Mata 2nd	16.0
"	" "	1985	"Bran"	16.0
4. Bandana	" "	1985	"Bran"	19.5
5. Aguilla	" "	1985	"Bran"	13.0
6. Unknown	" "	1985	"Bran"	18.1
7. Odra	"	1985	"Bran"	8.9
"	" "	1985	"Bran" (White)	9.0
8. Unknown	" "	1985	"Bran"	18.5
9. Unknown	Tacurong, Mindanao	1983	"Bran"	13.6, 12.7
10. Unknown	ILOILO	1984	DKB[1]	9.5, 9.5
11. Midway	"	1984	DKB[1]	17.4
12. New Pavia	"	1984	DKB[1]	17.4
13. P.R. Blancaflor	"	1984	DKB[1]	16.7
14. Mosqueda	"	1984	DKB[1]	12.0, 12.1
15. Oton	"	1984	DKB[1]	18.4
16. Jeben	"	1984	DKB[1]	11.4
17. Glory	"	1984	DKB[1]	13.6
18. San Jose	"	1984	DKB[1]	15.6
19. Evelyn	"	1984	DKB[1]	16.6
20. (NFA Cono-type)[2]	Tacurong, Mindanao	1984	"Bran"	19.1, 19.2
Average			DKA	18.1
Average			DKB	15.5
Average			DKA + DKB	16.6
Average			"Bran"	15.2

1. Millers were requested to provide a sample of DKB; collection was not supervised.
2. Government owned mill.

DKA is the rice bran removed on the second stone and that passes through the screen surrounding the second stone. The whole kernel rice is often scalped after both the first and second stone polishers and the material that passes through the scalping screen is called mata mata (germ and small broken rice). All of these materials can be combined and called "bran" or they can be retain as separate items to be marketed as such. It is not uncommon for millers to add hulls or pulverized hulls to the bran. In obtaining "bran" from private millers, one must be careful to specify the product which is desired. Samples of rice bran from 20 private millers throughout the Philippines has been analyzed for fat content. Table II provides the results and suggests that high fat (15-19%) content rice bran is obtainable from private millers if properly specified and monitored.

2. Rice Bran Oil - NFA Tacurong Experience. Crude Rice Bran Oil (CRBO) has been produced by NFA at Tacurong, Mindanao since 1982. In 1985, the process entailed milling palay on a 30 MT palay/hour two-stage Buhler rice mill from 8 am to 2pm each day. The rice bran is continuously steam pelleted (4.5 x 10 mm) but not stabilized. In 1985, the free fatty acid content was reported at 3.5% in the palay and 6 to 7% by the time the bran pellets were extracted with hexane. Extraction commenced at 2 pm and ran until 10 pm (Electrical power availability was insufficient to run both the Buhler rice mill and the 30 MT/day horizontal basket-type extractor (Lurgi) at the same time.) Extraction time is 2-hours at 63 to 66°C. Miscella leaving the extractor at about 12% oil is charged into a double effect evaporator (first evaporator 70°C; second evaporator 85 to 90°C) to remove a large portion of solvent. Finally, the liquid leaving the evaporator is pumped into a stripping column (110°C) to remove the remainder of solvent in the oil. Extracted bran is placed into a desolventizer/toaster unit to remove residual hexane. Hexane loss in the system is about 0.75%. CRBO

produced is completely opaque and of charcoal color. CENAPRO, one of the refiners that processed Tacurong CRBO, noted its FFA content ranged from 7.9 to 16.7% and averaged 11.3%.

A CENAPRO consultant to NFA Tacurong noted defatted rice bran pellets had a "high" residual fat content which he attributed to solvent channeling during extraction and insufficient drainage of solvent following extraction and before loading the pellets into the desolventizer toaster. The consultant recommended increasing the pellet diameter to one-quarter inch and increasing their density with more pelleting pressure. To remove impurities (fines) from the CRBO and improve is refining quality, he recommended filtering the CRBO using 3 to 5% additive composed of one-third filter aid and two-thirds NFA Tacurong black ash (presumably rice hull ash).

In 1984, NFA prepared "Estimated Production and Dispersal Costs of Rice Bran Oil (Tacurong)"[8]. Table III summarizes these estimates and shows the sum of production, refining, packaging, and distribution costs ranged from 50.4 to 80.6 pesos ($3.60 - 5.76) per gallon refined oil. In May 1984, corn and soybean oils were selling at a near record retail peak of 140 to 150 pesos ($10 - 10.71) per gallon and suggests rice bran oil of good quality would be highly competitive. NFA's price for rice bran oil was 81 pesos ($5.78) per gallon which was raised to 124.7 pesos ($8.91) July 26, 1984. Table IV converts Table III data to cost per MT of material processed. Extraction cost of rice bran, including pelleting the bran, ranged from 328 to 915 pesos ($23.45 to 65.35) per MT. Table V shows the breakdown of total production and dispersal costs by percentage. Extraction cost ranged from 37.9 to 55.3% of total costs.

produced is completely [illegible] and [illegible] [illegible]

reflects that [illegible] ([illegible]) [illegible]

to 16.7% and averaged [illegible].

[illegible]

[illegible]

production and [illegible]

17.0 to 23.1% [illegible].

TABLE III

Projected Production and Dispersal Costs of Rice Bran Oil Per Year.
Tacurong Operations. NFA/GOP 1984.

Assumptions:

Rice Bran (RB)	3636 MT/Year	1674 MT/year
Crude Oil Recovery	400 MT (11% of RB)	184 MT (11% of RB)
Percentage of Extraction Capacity Utilized	46.6%	21.5%
Refined Oil Recovery	200 MT (50% of Crude)	110 MT (60% of Crude)

Cost of Hexane/Liter------------------- 6.5 Pesos ----------- 18.375 Pesos ---------- 20.2 Pesos
$US = 14 Pesos

	Pre June Oil/ Labor Wage Hikes		After June Oil/ Labor Wage Hikes		Projection by Second NFA Group	
	Pesos	Dollars	Pesos	Dollars	Pesos	Dollars
Rice Bran	4,181,354	298,668	5,272,142	376,582	2,677,760	191,269
Credit for Defatted RB - 89% Yield	4,206,805	300,486	5,177,607	369,829	2,677,760	191,269
Extraction Costs	1,193.645	85.258	1,800.400	128,600	1,531,614	109,401
Hexane (12 liters/MT RB)	283,604	20,257	801,729	57,266	405,777	28,984
Mineral Oil	--	--	--	--	18,120	1,294
Labor	150,291	10,735	165,320	11,809	126,077	9,006
Maintenance, and Repairs	180,000	12,857	216,000	15,429	180,000	12,857
Insurance	176,760	12,626	176,760	12,626	176,000	12,571
Depreciation	350,720	25,051	350,720	25,051	350,720	25,051
Power	52,270	3,734	89,871	6,686	274,920	19,637
Dispersal Costs (Transport) (Crude Oil from Tacurong to Cebu)	219,150	15,654	275,986	19,713	124,222	8,873
Refining Costs						
Refiner Also Receives Acid Oil/Wax	1,129,875	80,705	1,249,861	89,276	728,640	52,046
Packaging - Half-Gallon Tins	564,715	40,337	674,550	48,182	339,059	24,219
Distribution -Manila	70,400	5,029	82,867	5,919	48,300	3,450
Total Costs	3,152,334	225,165	4,178,199	298,443	2,771,835	197,989
Per Gallon Oil in Half-Gallon Tins, 3.2 kg.	50.4	3.60	66.8	4.78	80.6	5.76
With 5% Overhead	53.0	3.78	70.2	5.02	84.6	6.04
With Interest Expense (26% PA for 6 months)	60.0	4.30	79.6	5.70	96.0	6.86

TABLE IV

Projected Production and Dispersal Costs of Rice Bran Oil in Half-Gallon Tins, Tacurong.
Costs Reported per MT of Indicated Material. NFA/GOP 1984.

Assumptions:

Rice Bran (RB)	3636 MT/Year	1674 MT/year
Crude Oil Recovery	400 MT (11% of RB)	184 MT (11% of RB)
Percentage of Extraction Capacity Utilized	46.6%	21.5%
Refined Oil Recovery	200 MT (50% of Crude)	110 MT (60% of Crude)

Cost of Hexane/Liter------------------- 6.5 Pesos ----------- 18.375 Pesos ---------- 20.2 Pesos
$US = 14 Pesos

	Pre June Oil/ Labor Wage Hikes		After June Oil/ Labor Wage Hikes		Projection by Second NFA Group	
	Pesos/MT	Dollars/MT	Pesos/MT	Dollars/MT	Pesos/MT	Dollars/MT
Rice Bran	1150	82.14	1450	103.57	1450	103.57
Credit for Defatted RB - 89% Yield	1300	92.85	1600	114.29	1629	116.37
Extraction Costs/MT RB	328	23.45	495	35.37	915	65.35
Hexane (12 liters/MT RB)	78	5.57	220	15.75	242	17.31
Mineral Oil	--	--	--	--	11	0.77
Labor	41	2.95	45	3.25	75	5.38
Maintenance, Insurance, Depreciation	195	13.90	204	14.61	422	30.16
Power	14	1.03	25	1.77	164	11.73
Dispersal Costs/MT Crude Oil (Crude Oil from Tacurong to Cebu)	548	39.13	690	49.28	675	48.22
Refining Costs/MT Refined Oil						
Refiner Also Receives Acid Oil/Wax	5650	403.57	6250	446.43	6600	471.43
Packaging - Half-Gallon Tins, Cost/MT Oil	2824	201.68	3373	240.91	3082	220.17
Distribution -Manila, Cost/MT oil	351	25.09	414	29.60	439	31.36
Total Cost/MT Oil	15762	1125.87	20891	1492.21	25199	1799.89
With 5% Overhead	16550	1182.17	21936	1566.82	26458	1889.89
With Interest Expense (26% PA for 6 months)	18785	1341.76	24897	1778.35	30030	2145.02

TABLE V

Percentage Breakdown of Projected Costs for Rice Bran Oil Production at Tacurong, Refining at Cebu, and Distribution in Manila in Half-Gallon Tins. NFA/GOP 1984.

	Percent of Total Costs		
	Pre June Oil/Labor Wage Hikes	Post June Oil/Labor Wage Hikes	Projection by Second NFA Group at Lower Production Rate
Rice Bran with Credit for Defatted Rice Bran	-0.8%	2.3%	0.0%
Extraction (Lurgi horizontal basket; 30 MT/day)	37.9	43.1	55.3
Dispersal (transport) Costs	7.0	6.6	4.5
Refining1/	35.8	29.9	26.3
Packaging; Half-Gallon Tins	17.9	16.1	12.2
Distribution; Manila	2.2	2.0	1.7
	100.0	100.0	100.0
% of Extractor capacity used. (30 MT RB/day; 260 days/year	46.6%	46.6%	21.5%

1/ Does not include value of acid oil and wax by-products also received by refiner in part payment for services.

As can be seen in Tables III and IV, NFA received a 13 to 15% premium for defatted rice bran which largely offset the cost of raw rice bran used for the extraction. The estimated yield of 11% crude oil suggests the fat content of the raw rice bran is on the order of 12 to 13% which is similar to NFA rice bran produced on Satake mills (Table I). As noted in Table III, refiners also receive the acid oil and wax by-products as part of their payment. If recovery of these products is 30% of crude oil and their market value is 10,000 pesos ($909) per MT, the actual cost of refining should be increased by 6,000 pesos per MT refined rice bran oil. CENAPRO claimed they did not recover acid oil.

Table VI provides analyses of refined rice bran oil from three different refining runs of Tacurong crude oil and also provides NFA's Technical Standards for its Kadiwa brand rice bran oil. Some critical comments received from a few institutions that were provided samples of the oil indicated: 1) The smoke point is too low, 2) The oil is darker than corn oil, 3) Chicken and donuts absorb too much oil during frying, 4) The oil cannot be used for salads. Smoke point is adversely affected by a high FFA content and by contamination with low smoke point oils such as coconut oil. Also, oil stored in tins shows a relatively higher rate of increase in FFA than when stored in glass or plastic containers (Rice Production and Utilization. 1980, Avi Publishing, p. 783). Significant quantities of NFA rice bran oil have been stored in tins in excess of one year before sale.

In June 1984, Harper, O'Deen, and Tribelhorn, Colorado State University (CSU), reported on their evaluation of Kadiwa Rice Bran Oil. Results of physical tests are shown in Table VI. Compared to other rice bran oils, the Kadiwa oil was "significantly darker". A sensory panel found the Kadiwa oil

TABLE VI. Analyses of NFA Rice Bran Oil Refined from Tacurong Crude Oil and Technical Standards for NFA Kadiwa Brand Rice Bran Oil

STATISTIC OR CHARACTERISTIC EVALUATED	REFINER AND YEAR				NFA KADIWA BRAND STANDARDS	CSU ANALYSIS OF KADIWA RICE BRAN OIL JUNE 1984
	RICOR1/ 1983	CENAPRO1/ 1984	CENAPRO & RICOR1/ 1985			
Crude RBO imput, MT	50.34	23.00	32.50		-	-
Total Refined RBO, MT	24.88	14.00	14.32		-	-
Recovery, %	49.4	63.7	44.1		-	-
Apportionment of packaging:						
1-gallon tins	4615	204	-		-	-
half gallon tins	6320	617	420		-	-
5-gallon tins	-	765	803		-	-
Analysis of Refined RBO1/						
Acid Value	-	-	-	-	0.11	0.182
Free Fatty Acids as Oleic, %	0.1	0.048	0.0807,	0.1	0.055	0.091
Color, Y	35.0	37.8	35.7,	35.0	22.1	60.0
R	9.0	12.6	7.0	5.0	6.8	6.0
Peroxide Value	1.0	1.3372	1.272	1.0	0.49	-
Moisture & Volatile Matter, & Insoluble Purities, %	0.15 Max	-		0.15 Max.	0.037	-
Specific Gravity	0.916-0.919	-		0.916-0.919	-	0.915
Refractive Index	1.47-1.473	-		1.47-1.473	-	1.4703
Saponification Value	181-189	-		181-189	187.1	195.0
Iodine Number	92-115	89.04		92-115	103.2	98.0
Unsaponifiable Matter	3.5 Max.	-		3.5 Max.	2.90	-
General Condition	Clear, Bland	-		Bland	-	(See text)
Cloud Test	-	Passed		-	-	-1°C
Smoke Test2/	-	-		-	356°F Minimum	-

1/ RICOR and CENAPRO are commercial oil refiners in Cebu. Analyses are by the refiner.

2/ There is a linear relationship between the logarithm of FFA and smoke point temperature (Fat and Oils; Bailey). 0.1% FFA gives a smoke point of 380°F; 0.08% FFA, 387°F; 0.04%, 408°F.

to have off aromas and taste. The aroma was described as "stale" and "oily". The taste was described as "oily", "sharp", or "stale". When used to prepared popcorn, the sensory panel detected off flavors described as "slightly bitter" and "slightly" rancid".

3. Polyunsaturated Vegetable Oil Markets. There are three market areas: 1) Consumer retail, 2) Institutional, and 3) Industrial. Based on a retail audit (October 1984 - March 1985), Dealer Pulse found annualized sales of 354 MT of corn and soy oils in supermarkets (3 checkout counters or more) in Greater Manila (7.7 million population) and 9 MT in Grocery stores (less than 3 checkout counters). Metro Manila is the only significant consumer retail market for corn and soy oils.

A major marketer of corn and soy oils in the Philippines noted that consumer and institutional markets would dip below 1,000 MT in 1985 compared to 2,500 MT in 1983. They attributed this to a widening price gap between coconut oil and corn/soy oils at retail (coconut selling at one-third corn/soy oil) and the declining economic performance of the country and consequent erosion of purchasing power. Subtracting the 361 MT retail market observed by Dealer Pulse from the 1,000 MT retail plus institutional markets leaves 639 MT as an estimate for institutional markets in 1985.

NFA in October 1985 estimated Philippine food oil consumption at 160,000 MT per year of which 97% is coconut oil and 3% is "all other". Of the all other, 80% or roughly 3,000 to 4,000 MT is corn oil. NFA further estimated that annual corn oil markets were 90% industrial (2,700 - 3,600 MT), 8% institutional (240 - 320 MT), and 2% consumer retail (60 - 80 MT).

to have off aroma and taste. The aroma was [illegible] "fatty" [illegible] "oily". The taste was described as "oily", "rancid", [illegible] "stale" [illegible] In general consumers [illegible] the keeping [illegible] ... "slightly bitter" and "stale [illegible]" [illegible]

4. Polyunsaturated [illegible]

areas [illegible]

a [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

A major [illegible]

since [illegible]

to 6,000 [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

NCA in October 1980 [illegible]

50 per year [illegible]

about 800 [illegible] roughly 3,000 to 6,000 [illegible]

that annual [illegible] would [illegible]

institutional [illegible]

In December 1983, US Consultant, Stephen Bogyo, reported on his findings: 1982 domestic coconut oil supply was 1,300,000 MT of which one million MT were exported, 135,000 MT retained for domestic industrial uses, and 75,000 MT for domestic food. Bogyo, quoting producers in Cebu City, reported 15,000 MT of corn oil production/year largely for food. Soy oil was reported at 2,000 MT in 1982.

4. NFA Rice Bran Oil Marketing Experience. NFA has marketed rice bran oil in both the retail and institutional markets starting in August 1983. The retail sales were made through the "Central Office Kadiwa Center" (COKC) where NFA/Manila employees often shop. The COKC is one of NFA's stores in its chain of Kadiwa stores which primarily serve a lower socio-economic clientel. As seen in Figure 1, rice bran oil sales were significant when its price was competitive with coconut oil (corn and soy oils are not marketed at Kadiwa stores). A survey of customers at the COKC in October 1984 revealed price was the primary consideration in buying a cooking oil. A second major point raised was quality, that is, customers indicated that the brand of coconut oil they used was well refined or the Kadiwa rice bran oil was poorly refined and had a bitter after taste. Lack of customer comments on the potential advantages of rice bran oil such as the ability to fry at higher temperature due to a higher smoke point, reduced oil absorption during frying resulting in lighter foods, and being less cholesterolgenic indicate poor knowledge of the product. This is understandable since there was no advertisement or educational effort associated with the marketing of rice bran oil.

Institutional sales of rice bran oil by NFA are shown in Figure II. Where price competition with coconut oil seemed to dominate the COKC retail

In December [illegible] 18 companies [illegible] Kingdom [illegible] purchased [illegible] 1982 annual [illegible] 80,000 MT of which [illegible] million MT were [illegible] and 25,000 MT for [illegible] reported 15,000 MT [illegible] was reported [illegible] MT in 1984.

4. WFA Ring [illegible] oil in 1983 [illegible] The retail [illegible] where WFA/Ma[illegible] its chain of [illegible] clientele. As seen in Figure [illegible] its price was competitive with [illegible] marketed at Kaduna [illegible] 1984 revealed price was the [illegible] A second major point [illegible] the brand of coconut oil [illegible] was [illegible] oil was poorly marketed and [illegible] ments on the [illegible] advantages of [illegible] fry at higher temperature [illegible] tion during frying resulting in lighter [illegible] oil indicate poor knowledge of the product [illegible] there was no advertisement [illegible] marketing of [illegible] oils.

The historical sales of [illegible] oil by WFA are shown in Figure [illegible] where price competition with [illegible]

FIGURE I

Effect of Price on Retail Sales of Kadiwa Rice Bran Oil at the Central Office Kadiwa Center Store.

(Rice Bran Oil Extracted at NFA/Tacurong and Refined by RICOR or CENAPRO at Cebu)

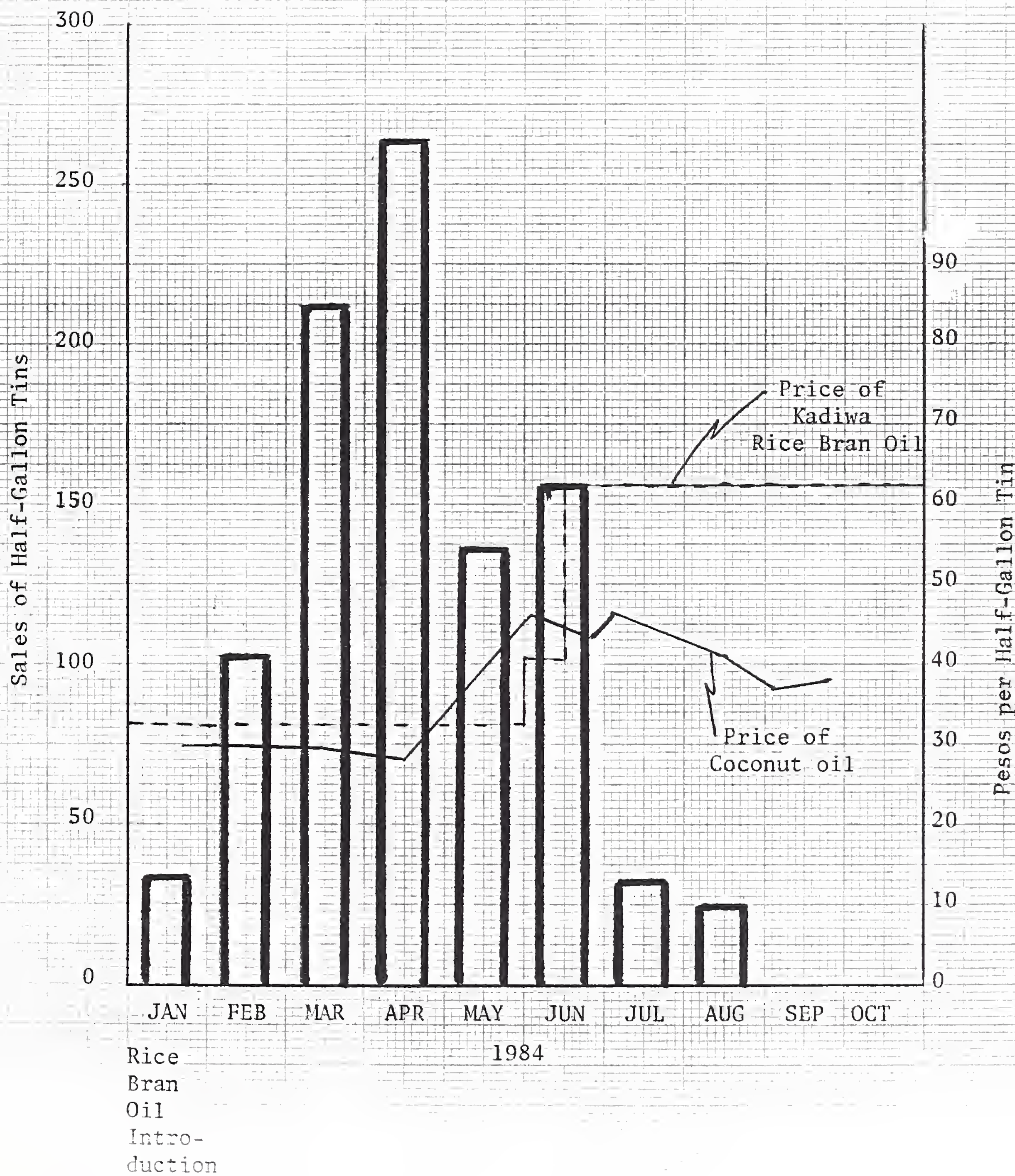
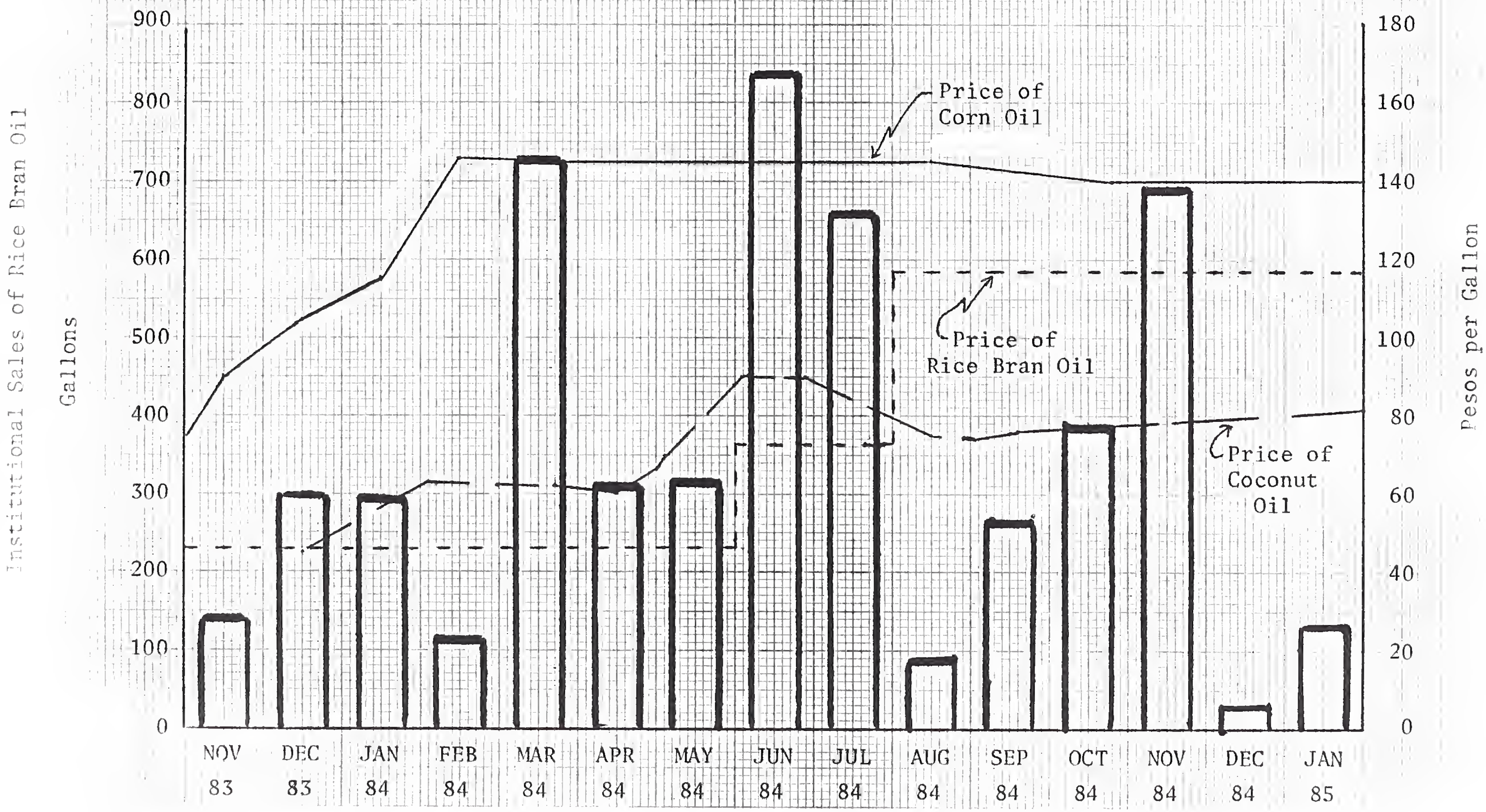


FIGURE II.

Effect of Price on Institutional Sales of Rice Bran Oil.
(Rice Bran Oil Extracted at NFA/Tacurong and Refined by RICOR or CENAPRO at Cebu)



sales of rice bran oil, it appears the purchasing motivation in the institutional market is different and there is a market for rice bran oil at a price above that of coconut oil. This suggests institutional buyers know that rice bran oil, when well refined, is similar to corn and soybean oils and they are willing to pay a premium over coconut oil to obtain it. However, there is evidence that institutional users have not found the rice bran oil to be well refined (see comments under "Rice Bran Oil - NFA Tacurong Experience", page 13) and that this impedes institutional sales.

Potential Private-Sector Extractors for Rice Bran Oil. Three companies have been identified with oil extraction capability and indicating an interest in working with the project: 1) Universal Robina Corporation (URC), Manila, 70-120 MT oilseed-extraction capacity/day; 2) CENAPRO, Cebu City, 150 - 250 MT/day; and 3) RICOR, Cebu City, 50 - 100 MT/day. Both CENAPRO and RICOR have carousel-type extractors. URC's extractor is a Lurgi basket-type. Only the URC extractor is being considered for use in conjunction with stabilized rice bran (SRB) to be produced at Cabanatuan. Its operation on SRB would be similar to that with corn germ except the cooking and flaking operations would be by-passed. Engineer Caballes, URC has expressed concern about "fines" (through a 20 mesh screen) in SRB. US consultant, George Kopas[9] has suggested 2 to 4% water could be sprayed on the SRB to "agglomerate" fines and improve percolation in extraction. Kopas has also suggested that extraction could be tried at 25-35°C, instead of the normal 60-65°C, to reduce the amount of waxes in the CRBO. He further recommends that the CRBO be hot (60 - 80°C) filtered before refining and that this could be done by URC. Hot filtering removes "impurities" or "fines" that

sales of vise [illegible] it shows [illegible] purchasing [illegible] in the

farmers market is different and there is [illegible]

price [illegible] of [illegible]

that [illegible]

and they are willing to [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] suggested that [illegible] would be [illegible]

[illegible] to reduce the amount of [illegible]

that the [illegible] be not (60 - 80%) [illegible]

could be [illegible] by [illegible]

otherwise foul the centrifuge used in the neutralization step in refining. Hot filtering was not being done by NFA/Tacurong and both RICOR and CENAPRO had problems in refining the Tacurong CRBO.

6. Potential Private Refiners for Crude Rice Bran Oil (CRBO) from SRB. Four companies have been identified with refining capabilities and indicating an interest in working with the project: 1) CENAPRO, Cebu City, 10 - 25 MT crude oil refining capacity/day; 2) RICOR, Cebu City, 25 - 50 MT/day; 3) CMC, Metro Manila, capacity unknown; and 4) URC, Manila, capacity unknown and lacks winterization capacity. Evidently, URC refining equipment has not been in use for some time. URC has disc-type DeLaval centrifuges for use in the neutratization step and a relatively modern semi-continuous DeSmet deodorizer that would yield a higher quality oil than the batch, black-iron deodorizer that CENAPRO has.

CENAPRO, RICOR and CMC refine corn oil and both CENAPRO and RICOR have refined NFA Tacurong CRBO. In 1985, NFA was in the process of installing a 1 MT/day refinery at Tacurong. NFA plans to refine their own Tacurong CRBO in the future.

CENAPRO has commented of the refining of NFA Tacurong CRBO as follows: 1) The CRBO had high levels of impurities and gums. CENAPRO used settling to remove these impurities. Oil in the residual sediment was significant and was lost due to lack of appropriate filtering equipment. 2) The alkali refined oil was bleached twice in an attempt to overcome its very dark color causing additional oil loss. 3) A heavy "stearine" load built up on filters after winterization significantly slowing the process, and 4) Refining capacity was reduced about 50% compared with corn. No details are known for the RICOR or URC refining processes.

FIGURE III.

CENAPRO RICE BRAN OIL REFINING PROCESS[a] Cebu, Philippines March 1984		Comments by US Consultant George Kopas on visiting CENAPRO in April 1984.
Crude Rice Bran Oil		
Preliminary Filtration	Sludge	CENAPRO used settling to remove impurities (fines). Appropriate filters are not available.
10-15% FFA		
Refining "Stepwise Method"		
8% FFA		
Neutralization w/Sharples centrifuge continuous, 500 kg/hr	(a) Neutralization - 80°C (b) Washing - 80°C (c) drying - 140-190°C	50% of losses during neutralization should be recovered as "acid oil".
58-69 Yellow, 20 Red; 0.05% FFA		
Bleaching Batch Type, 6 Tons	3% Fuller's Earth 3% Activated Carbon 1% Filter Aid 90-100°C, 700mmhg	In the US, carbon is used at 10% of activated earth, e.g, 5% activated earth plus 0.5% carbon. This is effective but cheaper,
45 Yellow 11-12.5 Red		
Deodorization Batch Type	250°C, 5-7 millibar	Black iron construction. Operated at 190°C and 15 to 20 mm Hg. Batch is 5 to 6 MT and cycle is 10 hours. (US refiner use stainless steel, 250°C and less than 10 mm Hg.[b]
Winterizing Batch Type	6-10°C	5 MT batch. Winterizing is normally done before deodorizing to reduce exposure of the oil to oxygen before packaging.
	Filter, Package.	

a. Provided by CENAPRO

b. Kopas notes that alkali refining brings FFA's down to about 0.1%. The 250°C and less than 10 mm Hg deodorizing treatment will further reduce FFA's to about 0.05% (smoke point over 400°F).

Figure 3 provides some details of the CENAPRO refinery. In processing NFA Tacurong CRBO, CENAPRO said they did not recover any acid oil which has value in feeds. According to Kopas[9], at least 50% of the refining loss in the neutralization step should be recovered as acid oil. In CRBO with 10% FFA, Kopas[9] estimated neutralization losses of 27%, thus one would expect a minimum yield of 13% acid oil. Kopas estimated an overall yield of refined rice bran oil of 62.6% when CRBO of 10% FFA and hot filtered to remove impurities was processed. Both RICOR and CENAPRO used settling instead of hot filtering and their yields of refined rice bran oil were 44 to 64%. (Table IV).

In March 1984, CENAPRO was reported to be installing a new refinery for corn oil. The old refinery would then be dedicated to coconut and rice bran oil processing. Because coconut oil has a very low smoke point temperature, extreme care would be necessary to prevent contamination of the rice bran oil with coconut oil.

CMC's interest in refining CRBO relates to their interest in developing a low-cost supply of a polyunsaturated vegetable oil for their internal use in margarine, mayonnaise and other food products (industrial use). CMC affiliates in Japan have full rice bran oil experience that could be drawn on.

H. Updated Profit (Loss) Estimate for Rice Bran Stabilization, Oil Recovery, and Marketing Project. For Details, See ANNEX I.

1. Executive Summary

A. PRODUCTION DATA

1. STABILIZATION OF RICE BRAN AT CABANATUAN BY NFA.

a. Rated capacity of rice bran stabilizer is 450 Kg per hour.

b. Ooerations are to be 10 hours per day, 22 days per month.

c. Operating efficiency is projected at 80%.

d. Recovery of stabilized bran is 92.5% of raw bran.

e. Procurement cost of rice bran is: P 2.0/Kg.

f. Private sector bran is used. It will average 15.0% fat content, as is.

2. EXTRACTION

a. Universal Robina Corporation, Bagong Ilog, Pasig, Metro Manila.

b. Estimated extraction capacity is 70 MT/day; Lurgi type.

c. Delivery of stabilized bran shall be made every quarter.

d. Recovery rate of crude oil shall be 12.0% of stabilized bran.

e. Crude oil shall average 10.0% free fatty acids.

3. REFINING

a. Recovery rate of refined oil from crude oil is 50.0%.

b. CENAPRO, Mandaue, Cebu City.

c. Estimated crude oil refining capacity is 25 MT/day.

d. Total production of refined oil per year is 52.7 MT or 3,103 five-gallon tins.

4. SEE TABLE VII FOR ANNUAL QUANTITIES OF PRODUCTS PROCESSED/PRODUCED.

B. TOTAL PROJECT COST

The project requires an initial investment of P 1,744,815 for the purchase/acquisition of the project's various fixed and current assets to be distributed as follows:

First quarter	-	P 734,894
Second quarter	-	900,017
Third quarter	-	54,952
Fourth quarter	-	54,952
Total		1,744,815

C. BUDGET REQUIREMENT

Budget requirement for the project is P 3,727,504 broken down as follows:

Capital Expenditures			
Installation		0 (P 80,000 already paid)	
Oil Tanks (24)	128,640	P 128,640	
Revenue Expenditures			
Procurement Cost (Bran)	P 1,939,080		
Stabilization Cost	485,936		
Extraction Cost	622,956		
Refining Cost	447,004		
Packaging Cost	75,092		
Dispersal Cost	21,348		
Distribution Cost	7,448		P 3,598,864
Total			P 3,727,504

D. PRODUCTION COST

Estimated production cost per five-gallon tin (17 KG) is P 702.52 Details are as follows:

	Amount	Percent
Procurement of raw materials	P 126.27	18.0
Stabilization Cost	156.60	22.3
Extraction Cost	200.76	28.6
Refining Cost	153.73	21.9
Packaging Cost	24.20	3.4
Dispersal Cost	6.88	1.0
Distribution Cost	2.40	0.3
Overheads	31.68	4.5
Total	702.52	100.0

E. PROFITABILITY (LOSS)

Based on the current selling price of P 600 per five-gallon tin, the computed net profit (loss) is : P (102.52) per five-gallon tin.

F. RETURN ON INVESTMENT (ROI)

Computed ROI is less than 0%.

G. PAYBACK PERIOD

The initial investment of P 1,744,815 will not be paid back in total.

2. Effects of Various Factors on Profit (Loss).

Figure IV (Curves 3 and 4) shows the important of Refining Yield (amount of refined oil recovered from crude oil) on the economics of rice bran oil. Refining experience at CENAPRO and RICOR (3 runs) have shown yields of 44, 49, and 64% when processing NFA Tacurong crude oil. Free fatty acids (FFA's) strongly effect refining yield with each 1% FFA's resulting in 2% loss of refining yield. Kopas[9] has estimated a 62.6% refining yield when FFA's are 10%.

Another strong determinant of profit (loss) is the yield of crude oil from stabilized rice bran. Figure IV demonstrates the effect. Of course, the yield of crude oil is largely determined by the fat content of the rice bran which has been discussed previously. It appears private sector bran could be purchased averaging on the order of 16% fat content of 2% in the defatted bran, on could expect to obtain a crude oil yield of 14% in the Philippines.

Recovering a 10% premium on defatted rice bran over full-fat rice bran provides a moderate economic benefit as shown in Figure IV when comparing curves 2 and 3.

The cost of stabilization is depicted in Figure IV by comparing curves 1 and 3.

Table VIII provides some of the calculations supporting Figure IV.

Table IX provides a list of "Considerations for Improving the Economics of Rice Bran Oil". See ANNEX I for details.

TABLE VII

PRODUCTION SCHEDULE

1. BRAN STABILIZED

	ANNUAL	
Annual ran bran requirement (79.2 MT/MO)	950.4	MT
Recovery from stabilization	92.5	%
Stabilized Bran- -	879.12	MT

2. CRUDE OIL RECOVERED

Stabilized Rice Bran for Extraction (73.26 MT/MO)	879.12	MT
Extraction rate	12.0	%
Crude oil recovered (8.7912 MT/MO) - - - - - - - - - -	105.4944	MT

3. DEFATTED RICE BRAN RECOVERED

Stabilized bran for extraction (73.26 MT/MO)	879.12	MT
Less crude oil recovered (8.7912 MT/MO)	105.4944	MT
Defatted rice bran recovered (64.4688 MT/MO) - - - -	773.6256	MT

4. REFINED OIL RECOVERED

Crude Oil Recovered (8.7912 MT/MO)	105.4944	MT
Refining rate	50.0	%
Refined oil recovered (4.3956 MT/MO) or - - - - - - - 258.6 five-gallon tins per month.	52.7472 MT or 3,103 five-gallon tins	

TABLE VIII

CALCULATIONS FOR FIGURE IV

REFINING YIELD 65%

	% Yield of Crude Oil			
	10	12	15	17
Crude Oil, KG	87,912.0	105,494.4	131,868.0	149,450.4
Refined Oil, KG	57,142.8	68,571.4	85,714.2	97,142.8
#Five-Gallon Tins of Oil	3,361.3	4,033.6	5,042.0	5,714.3
Sales of Oil; P 600/Five Gal.	2,016,960	2,420,160	3,025,200	3,428,580
Purchase of raw bran; P 2/KG	1,939,080	1,939,080	1,939,080	1,939,080
Sales Defatted Bran; P 2/KG	1,582,416	1,547,252	1,494,504	1,459,340
Procurement Cost of Bran Net	356,664	391,828	444,576	479,740
Stabilization Cost	485,936	485,936	485,936	485,936
Extraction Cost	619,893	622,956	627,550	630,614
Refining Cost	516,691	620,057	775,084	878,403
Packaging Cost	81,341	97,613	122,019	138,284
Dispersal Cost	23,126	27,752	34,691	39,317
Distribution Cost	8,068	9,682	12,102	13,715
Production Cost	2,091,719	2,255,824	2,501,958	2,666,009
Overhead, 4.723%	98,792	106,543	118,167	125,916
Total Cost	2,190,511	2,362,367	2,620,125	2,791,925
Profit (Loss)	(173,551)	57,793	405,075	636,655
Profit (Loss)/Five-Gallons Oil	(51.6)	14.3	80.3	111.4

REFINING YIELD 50%

Crude Oil, KG	87,912.0	105,494.4	131,868.0	149,450.4
Refined oil, KG	43,956.0	52,747.2	65,934.0	74,725.2
# Five-Gallon Tins of Oil	2,585.6	3,103.0	3,878.5	4,395.6
Sales of Oil; P 600/Five-Gal.	1,551,360	1,861,800	2,327,250	2,637,360
Purchase of raw bran; P 2/KG	1,939,080	1,939,080	1,939,080	1,939,080
Sales Defatted Bran; P 2/KG	1,582,416	1,547,252	1,494,504	1,459,340
Procurement Cost of Bran Net	356,664	391,828	444,576	479,740
Stabilization Cost	485,936	485,936	485,936	485,936
Extraction Cost	619,893	622,956	627,550	630,614
Refining Cost	397,487	477,004	596,255	675,724
Packaging Cost	62,575	75,093	93,866	106,377
Dispersal Cost	17,783	21,348	26,685	30,244
Distribution Cost	6,206	7,448	9,310	10,551
Production Cost	1,946,544	2,081,613	2,284,178	2,419,186
Overhead; 4.723%	91,835	98,315	107,882	114,258
Total Cost	2,038,479	2,179,928	2,392,060	2,533,444
Profit (Loss)	(487,119)	(318,128)	(64,810)	103,916
Profit (Loss)/Five-Gallons Oil	(188.4)	(102.5)	(16.7)	23.6

FIGURE 1V

Effect of Various Factors on Profitability of Rice Bran Oil Recovery and Sale. Market Price of Rice Bran Oil is Taken at P 600 ($US30) Per Five Gallon Tin.

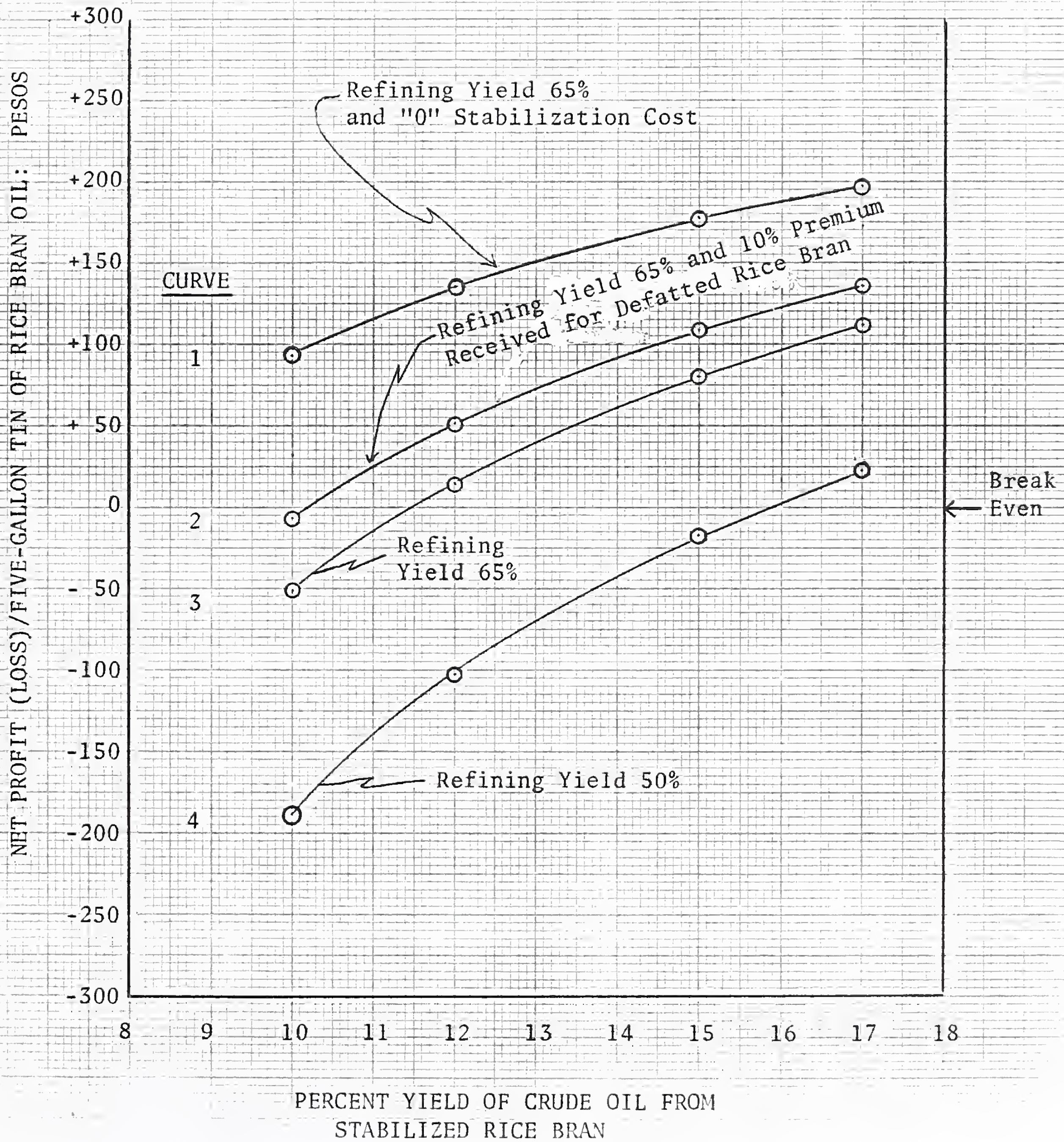


TABLE IX

CONSIDERATIONS FOR IMPROVING THE ECONOMICS OF RICE BRAN STABILIZATION AND OIL RECOVERY

1. Get a higher price for refined oil.

   a) A major impediment to this approach has been the poor quality of rice bran oil produced in the Philippines (NFA Tacurong experience). A better quality oil might compete directly with corn and soy oils which sell at up to P 750/five-gallons compared to the P 600 for rice bran oil.

   b. Export crude price bran oil to a country with an established rice bran oil refining industry that produces a high quality oil.

2. Get a premium for defatted rice bran.

   Some hog feed millers in the Philippines have utilized the level of protein in a feed material in establishing its value. This suggests that defatted rice bran, which has a higher protein content than full-fat rice bran, might be able to command a premium. Defatted rice bran has been successfully sold in limited quantities at a 10 to 15% premium at Tacurong by selling it during the off-milling season when regular full-fat rice bran is scarce.

3. Get a return for acid oil and waxes.

   This option requires an up-graded rice bran oil refinery as does item "1" above.

4. Reduce extraction costs.

   a) Reduce hexane loss below 12 liters/MT stabilized rice bran processed.

   b) Maintenance, insurance and depreciation expense levels at NFA Tacurong are based on operations at only 46.6% of capacity. These cost, which have been used in this estimate, may be less for Universal Robina.

c) Note, however, that the extraction fee used in this estimate does not include any profit margin for Universal Robina.

5. Reduce refining costs.

While NFA has substantial experience in contracting rice bran oil refining at CENAPRO and RICOR at Cebu City, US Consultant, George Kopas felt their quoted refining fees were "very high". A fee based on crude oil to be refined rather than refined oil produced would remove some risk for the refiner and could be the basis for negotiating a lower refining fee.

6. Utilize only private sector bran of high fat content.

It appears that CONO-type mills produce bran of higher fat content than NFA owned and operated Satake Rice Mills.

7. Reduce Stabilization Costs.

a) Recover value for sacks used in bran collection/handling and storage.

b) Install a larger extruder such that labor requirement are not increased but production is.

8. The use of 6% inflation for each of 3 years to adjust costs maybe inappropriate.

II. STATUS IN THE UNITED STATES

A. Riviana, Houston, TX

This company stabilizes rice bran at its Abbeyville, Louisiana rice mill using a Wenger 110-RB extruder. Wenger describes the extruder as having a capacity range of 80 to 160 kg/hour with rice bran (the Wenger 110-RB is a dry extruder; no steam capability). Processing conditions are described by Wenger as being 120°C with 10 to 20 seconds retention time. Riviana initiated extrusion cooking of rice bran when they closed down their Solvent Extraction Milling Plant at Abbeyville in the mid 1970's and lost their source of edible grade defatted rice bran (Protex). In order to retain their edible defatted rice bran market, the product was replaced with extrusion stabilized full fat rice bran. Production has been small with only 25% of capacity utilized (2-truck loads per month). The product has retained the Protex name. No information is available on Riviana processing costs. Product stability has been good.

Prior to closing the Abbeyville Solvent Extraction Milling (XM) plant, Riviana was a producer and refiner of crude rice bran oil (CRBO). Riviana produced 3,500 MT of refined rice bran oil per year. They noted that 10,000 MT/year is a minimum under U.S. market and economic conditions. Free fatty acids (FFA) were not a problem since the oil was extracted as the rice was actually being milled. Riviana could be a source of information on refining technology and yield of refined oil from CRBO.

Riviana was awarded US Patent No. 3,481,960 that describes the use of a special sodium silicate ($Na_2O:2.0SiO_2$) to assist dewaxing CRBO before alkali refining. The CRBO or miscella is cooled to 40°F, treated with a water solution of sodium silicate which causes flocculation of the waxes (2 to 3%), and centrifuged or filtered to remove the floc. Dr. J. Hunnel, Riviana

noted that 2 to 4% neutral oil is also lost. He explained that the siliate associates with the waxes increasing their specific gravity. The centrifugate is a slimy material that Riviana added back to feed bran.

B. Rice Bran Industries, Santa Monica, CA

This company was formed about 1983 by a group of Canadian investors (stock issued and listed on the Vancouver Exchange) with the purpose of developing and marketing food products utilizing stabilized rice bran (SRB). The company worked with Farmers' Rice Cooperative, Sacramento, California and Triple "F" Company, Des Moines, Iowa to have four Insta Pro-2000 extruders installed at Farmers'. Dr. Robin Saunders, WRRC/USDA reports that SRB is produced by extrusion at 145°C which is then immediately cooled.
Dr. Saunders considered rice bran (RB) at Farmers' to be of poor quality and low fat content (14 to 15%). Fat content has been reported to have been upgraded to 16 to 18% currently. Containers (16 or 35 MT capacity) of SRB have been produced and shipped to Taiwan for oil extraction. Specifications called for 18% fat but the delivered product fell significantly below this and was subjected to heavy penalties. One sample of SRB returned to the US from one of the containers showed 4% FFA indicating a slight rise over the level at time of production. Also, the Taiwanese subjected defatted SRB to an invitro "feed" test that showed it was inferior to regular defatted rice bran or defatted SRB from PIRMI.

Some 150 MT of SRB was produced in 1986 at Farmers' for a trial extraction (at 35 to 40°C) by Oilseeds International (George Kopas, President), Grimes, California in a Crown Extractor (horizontal belt type). Rice Bran Industries was happy with the extraction. Dr. Sayre, WRRC/USDA analyzed the defatted SRB and found it contained 0.9% fat content which was mostly waxes. Typically, extraction temperature is 60 to 70°C. Sayre degummed and dewaxed

a sample of the crude rice bran oil attaining a yield of 76.3% degummed/dewaxed oil. Gum loss was 14.3% and wax loss was 9.4%.

The purpose of the trial extraction was to obtain defatted SRB for use in food product development. However, Dr. Saunders recommended not using the defatted SRB because of its poor quality. The CRBO produced had 1.4% FFA but was not refined. Presumably, it was used for feed.

Investors have not been pleased with Rice Bran Industries' progress and negotiations are underway for the Brady Corporation, Torrance California to take it over.

C. Brady Corporation, Torrance, CA

Brady has owned and arranged for operation of a Brady extruder at PIRMI, Woodland, California since 1983. SRB is produced for sale to Pacific Rice Products International Company, Berkeley, California for food uses and for sale overseas for oil extraction. A second Brady extruder is being installed at PIRMI and additional units are planned.

In 1986, Brady organized installation of five Brady extruders at Comet Rice Mills, Maxwell, California. SRB produced at both PIRMI and Comet runs at about 20% fat. Extrusion conditions at both PIRMI and Comet are 130°C extrusion temperature and insulated holding of the extrudate at 95 to 100°C for 3-minutes before cooling.

Brady has worked with others to send trial shipments of SRB to Taiwan and Korea. Shipment was in 16 or 35 MT containers. Samples of SRB returned to the US have shown the product to be stable during shipment. While the receivers have been said to be pleased with the SRB, no details are known about the extraction, refining, and financial results.

Brady, who manufactures the Brady extruders, has a policy of not selling extruders for rice bran stabilization. Instead, if a party wishes to produce SRB, Brady will negotiate a joint venture where Brady provides the extruders and other equipment and certain managerial services. Presumably, the PIRMI and Comet operations are of this ilk. Brady has formed another such joint venture with MARKFED in India which is described under <u>Status in India</u> (page 35).

During 1986 Brady designed and built a prototype of a new extruder with smaller capacity, 100 to 200 Kg/hour. The unit is not yet in production. However, the unit has been successfully demonstrated on rice bran for short periods.

D. <u>Pacific Rice Products International, Berkeley, CA</u>

This company was started about 1983 by Mr. Curt Rocca (past owner and President of PIRMI) with the objective of utilizing SRB and other rice products in foods. He has developed a very popular crispy cracker that contains 10% SRB and has also developed a "Grapenut"-like breakfast cereal containing 10% SRB. Pacific Rice Products is utilizing about 7 MT SRB per week in its food products. SRB samples are currently circulating at most major U.S. food companies for consideration in replacing more expensive ingredients or for new product development. Rocca worked with Brady, PIRMI, and a Japanese Trading House in San Francisco to arrange the first shipment of containers of SRB to Asia (Japan) in 1985 for trial oil recovery. Conflicting reports have circulated on the success of this trial. BOSO Oil Company, Japan was one of the SRB recipients (see page 37 for further discussion).

E. <u>Archer Daniels Midland Company, Decatur, IL</u>

Mr. James Lindsay, ADM, Decatur told Dr. Saunders, WRRC/USDA in 1982 that ADM was extracting 1,200 tons of parboiled rice bran at Greenville,

Brady, who manufactures the Brady extinguisher, has a policy of not selling extinguishers for fire room installation. Instead, if a Navy bidder requires over 500, Brady will negotiate a joint venture where Brady provides the extinguishers and other equipment and [illegible] the [illegible] and [illegible] their [illegible] joint venture with [illegible] (Appendix 15).

[illegible]

[illegible]

[illegible]

[illegible] and a [illegible] of contractors of [illegible] in [illegible] 1990 [illegible] conflicting reports have circulated [illegible] Company. [illegible] was one of the [illegible] (Appendix [illegible]).

E. Archer Daniels Midland Company, Decatur, Il

Mr. James Lindsay, ADM, Decatur told Dr. [illegible] that ADM was extracting 1,200 tons of [illegible]

Mississippi. CRBO had 2.5% FFA and was sold at 14.6¢ per pound for feed. Defatted rice bran was pelleted and sold in Europe. ADM considered the possibility of extracting and refining CRBO from SRB provided by WRRC/USDA out of PIRMI but it was not accomplished.

F. WRRC, USDA: Albany, CA

1. Rice Bran Oil Refining. Sayre, Nayyar, and Saunders have published a paper (JAOCS 62(6):1040; 1985) describing laboratory experiments on extracting and refining rice bran oil from stabilized rice bran (SRB). In discussing refining loss, one must be careful to define how refining loss is determined. Evidently, refining loss can mean the loss from all processing steps following extraction including degumming and dewaxing, or it can refer to those losses incurred after the crude rice bran oil has been degummed and dewaxed or it can refer to only the loss occurring on neutralization. (see Table X).

Enochian *et al* (USDA Agric. Mkg. Res. Report No: 1120; 1981) probably erred substantially on the optimistic side in their financial feasibility study of rice bran stabilization and oil recovery by misinterpreting "refining yield" and ignoring losses in degumming, dewaxing, decolorizing, and deodorizing. Enochian *et al* used an overall total refining yield of 80% compared to Sayre et al's 62.1 to 66.1% for a CRBO of about 3% FFA (Table X). When Sayre *et al* calculated refining yield based on starting with degummed and dewaxed crude oil, the values ranged from 78.8% to 85.6%, similar to the value used by Enochian. Sayre et al's results do not include bleaching and deodorizing losses which are significant.

When Sayre et al degummed, dewaxed and neutralized an 11.2% FFA crude rice bran oil, the total refining yield was 47.1%. Starting with degummed and dewaxed crude oil, the refining yield was 61.9%.

Mississippi; CRRB had 2.5% FFA and was sold at 14¢ per pound for [illegible]. Defatted rice bran was collected and [illegible] [illegible] [illegible] the possibility of extracting and [illegible] out of [illegible] but it was not economic [illegible]

[illegible]

[illegible]

with degummed and dewaxed [illegible] value used by [illegible] indicating the [illegible]

When Sayre et al. [illegible] Saunders and [illegible] rice bran oil, the total refining yield was 47.1% [illegible] and degummed crude oil, the refining yield was 81.9%.

TABLE X

Laboratory Rice Bran Oil Processing (JAOCS 62(6):1040; 1985). Oil Extracted from Rice Bran Stabilized by Extrusion at 130°C and Holding at 99°C for Three Minutes Before Cooling.[4]

	Weeks of Crude Oil Storage at 23°C before Processing	
	0	6
% Moisture in bran	6.3	5.7
% Oil in bran, dry basis	20.0	19.3
% FFA in extracted oil	1.7	2.6
% Oil recovery, degummed[1]	82.8	88.2
% Oil recovery, dewaxed[2]	77.2	78.8
% Oil recovery, neutralized and washed[3]	66.1	62.1
% Oil recovery based on degummed and dewaxed oil	85.6	78.88

1. Degumming consisted of 1% water addition (w/w), mixing at 60°C, allowing to to settle overnight at 23°C, and centrifuging.

2. Dewaxing consisted of chilling at 2 to 3°C for 48 hours and centrifuging at 3°C.

3. No attempt was made to recover residual oil from gums, waxes, or soap stock.

4. Authors, Sayre et al, indicate that the proportion of transfer loss is relatively high in this laboratory study and thus yields should not be considered predictive of absolute values which would be obtained under industrial conditions.

Sayre et al observed that crude rice bran oil degummed immediately after extraction allows a cleaner "break" of soap stock in the neutralization step and also reduces the neutralization loss (Table X). According to Sayre, this observation is consistent with that observed by Takeshita (Trans. Kohushikan Univ. Dept. Eng. No. 5, page 1; 1972). It is thus recommended to degum crude rice bran oil shortly after extraction.

2. Feed Value of Stabilized Rice Bran. WRRC found no significant differences in the feed efficiencies for hogs between raw rice bran and stabilized rice bran fed at 40% of diet. Both raw and stabilized rice bran diets produced lower average daily weight gains than a control corn/soybean diet thus requiring several (8 to 14) more days to reach the 100 Kg slaughter weight. Even so, both diets resulted in pigs attaining weights of about 90 Kg under 5-months from farrow to finish, a normal dietary precondition expected in commercial practice. Accordingly, it was concluded that these brans would be satisfactory in swine rations when fed at the 40% level.

In poultry, an advantage of stabilized rice bran over raw rice bran has been demonstrated when the rice bran products composed 60% of the diet (Table XI). Furthermore, stabilized rice bran at 60% of diet and supplemented with 2.6% calcium carbonate showed chick growth equal to a corn-based chick chow.

G. Colorado State University, Ft. Collins, CO.

El Amin, working at CSU, examined the extraction characteristics of extrusion stabilized rice bran flakes and found a hexane flow rate of 563 to 620 liters per meter squared per minute ($1/m^2/min$) for a 60 cm bed and 58°C extraction temperature. Reiners et al (JAOCS 28:518; 1951) reported that a minimum percolation rate of 367 $1/m^2/min$ was required for a basket type extractor.

TABLE XI

Comparative Values of Raw and Stabilized Rice Brans in Poultry Diets

Ration[1]	Days from Hatch 16	30	42	55
	Weight gain in grams---Cummulative			
Raw Rice Bran	263	794	1429	2128
Raw Rice Bran + 2.6% $CaCO_3$	288	811	1368	2086
Stabilized Rice Bran	329	857	1312	1775
Stabilized Rice Bran + 2.6% $CaCO_3$	336	915	1614	2488
Corn-Based Chick Chow	381	997	1655	2437

1. Rice Bran incorporated at 60% of diet.

III. STATUS INDIA

A. Brady/Markfed Joint Venture, Rajpura, Punjab.

In April 1986, the Brady/Markfed Joint Venture installed a Brady extruder at a rice mill in Rajpura. The unit was started-up in June 1986 and has stabilized 500 - 600 MT of rice bran. A trial extraction of crude rice bran oil from the stabilized rice bran has been made. Details of the extraction are not available. Saunders, WRRC, has reported that Yoshino of Japan is working with a local refiner to upgrade its refining capacity to produce edible quality rice bran oil.

Brady has sent 12 additional extruders with ancillary equipment and the equipment is now in India awaiting installation. Details as to this expansion are unknown.

B. Rice Bran Oil Production and Politics.

Crude rice bran oil production in India has been estimated at 200,000 MT annually (1984) of which 30,000 MT is edible crude oil derived largely from parboiled rice bran. The extent of rice bran oil extraction is verified by its exports of defatted rice bran which in 1984 were 600,000 MT. In addition, 500,000 MT of defatted bran were used locally (Source: Indian Express 9/6/84). Crude oil extraction percentage was reported to be 14% (Source: Business India June 18 - July 1984). Regulations for rice milling in India limit the removal of rice bran to 5%.

Edible crude rice bran oil is defined as that which has less than 7% FFA's and therefore suitable for refining for edible oil. Dr. Saunders (WRRC; 1987) reports that edible crude rice bran oil sells for $U.S. 900 to 1,000/MT (unknown if this is degummed and dewaxed). The edible crude oil can be alkali refined to yield an end product or it can be further

processed after alkali refining by bleaching and deodorizing. A price for refined oil was reported by Saunders of $1,200 to 1,500/MT (degree of processing unknown). The Government of India's Standard for rice bran oil (IS 3448-1968) states that the bleached and deodorized oil shall have a maximum acid value of 0.5 (0.25% FFA) and maximum unsaponifiable matter of 3.0%.

Evidently, the Government of India provides a tax incentive to encourage producers of vanaspati (vegetable ghee where oil is partially hydrogenated) to incorporate rice bran oil. Some 9,000 MT of rice bran oil were used in vanaspati in the 1981-82 year.

High FFA rice bran oil in India is used primarily for soap production. Hydrogenation is often employed to produce harder soaps. A new process has been reported for making alpha olefins that are proposed for use in synthetic detergents.

India obviously has significant rice bran oil experience. The Solvent Extractors' Association of India located in Bombay would be a likely depository of much of this knowledge or know where the knowledge can be obtained.

C. Rice Bran Collection/Oil Extraction Trial.

Raw rice bran was collected and commercially extracted at Hospet (Karnataka), Andhra Pradesh within 24-hours of milling. The crude rice bran oil had 11% FFA. Experimental refining done at the Oil Technological Research Institute, Anantapur gave a refining yield of 58% when undewaxed oil was neutralized. Dewaxing the crude by centrifugation removed 6% of waxy sludge. Yield of refined oil from dewaxed crude was 69% (64.9% from undewaxed). The refined oil was bleached with 3% activated earth and carbon and the final oil had 0.25% FFA and 3.0% unsaponifiable matter. Source: Res. and Ind. 28(3)167; 1983; India.

IV. STATUS IN KOREA

A. Shin Yang Rice and Oil Company, Seoul.

This company operates a rice bran collection, rice bran oil extraction, and refining business at Jeonju about 150 miles southwest of Seoul. Dr. Saunders, WRRC, reports that this ongoing business produces rice bran onsite and collects rice bran from about 100 local millers using a fleet of 150 trucks. During winter months, rice bran averages 10% FFA's before processing (pelleting?) and extraction and 15% FFA's in the summer. Refining yield is 72 - 75% but it is unknown if this figure includes degumming, dewaxing bleaching, and deodorizing losses or only the alkali refining loss. Evidently, this Company profitably extracted imported stabilized rice bran of 20% oil and 2.3% FFA (PIRMI, Woodland, CA) at $U.S. 200/MT landed cost. Local rice bran costs were given as $125/MT f.o.b. local mills. Dr. Khee Rhee, Texas A&M and consultant to Shin Yang noted there were rotary and horizontal chain-type extractors in Korea. Residual oil in extracted rice bran ranges from 0.5 to 1.5%.

B. Korean Institute of Science and Technology (KIST).

This organization has designed, built and tested an extruder for rice bran stabilization.

C. 1958 Process and Feasibility Study for Rice Bran Oil.

This is a comprehensive document providing much information (1958 time frame) on rice bran oil processing and experience. It includes discussions on advantages and disadvantages of various types of extractors. Some data/information specifically on Korea are as follows. Average yield of rice bran from rough rice (paddy) is 8%. Average rice mill has 35 MT paddy/day capacity. Average oil content of rice bran is 18%. Rice bran oil without hydrogenation can be substituted for part of imported tallow

used in soap manufacture. Rice bran stored one day at 20°C had 9.2% FFA's. There are 86 rice mills within 47 Km of Seoul producing 296 MT rice bran/day.

V. STATUS IN JAPAN (Source: K. Rocca, Pacific Rice Products Int'l., Berkeley, CA.)

A. BOSO Company Experience with Stabilized Rice Bran.

BOSO receive about 15 MT (1 container) of SRB in the summer of 1985. The SRB was manufactured by PIRMI, Woodland, California. BOSO used a French Rotary Extractor to recover crude oil. They noted that the flakes "compacted" during extraction. Extracted flakes had a residual oil content of 8.0% but BOSO said they could improve on this. The extracted crude oil had 2 to 4% FFA.

B. SRB Shipment Problem.

SRB was directly fed to a 16 MT shipping container at PIRMI, Woodland, California at 40°C. The container was shipped to Osaka, Japan for trial extraction by a second Japanese rice bran oil extractor. The SRB "heated" enroute and there were burnt spots when received. No details are known on any subsequent processing.

C. Rice Bran Oil Production.

Estimates indicate 90% of Japanese rice bran is extracted yielding perhaps 120,000 MT crude rice bran oil. Most of this is refined, bleached and deodorized to produce high grade salad and cooking oils.

A unique aspect of rice processing in Japan is the tradition of storing rice as brown rice under cool conditions. FFA's develop slowly in brown rice thus FFA's are often already elevated by the time the rice is polished. Once produced, rice bran is collected quickly, transported to the extractor, steam agglomerated (sandy texture), and extracted as soon as possible.

Oil extraction use to be primarily by batch extractors but these have been largely replaced by continuous units. (see page 45. According to

Y. Takeshita, batch and battery type extractors are still widely used in Japan as of 1982). Okinawa Food Company, a BOSO subsidiary, uses a batch extractor and then transport the crude oil back to Japan. Dr. Saunders, WRRC, reports that while most refining is by the alkali process, a new technology is "physical refining" where FFA's are distilled off with steam under vacuum resulting in improved refining yields. However, FFA levels cannot be too high if the process is to be effective (economic).

Defatted rice bran receives a 20 to 25% premium in Japan being used in poultry formulations where protein is of significant value. Mr. Rocca noted that in California, computers note the lower metabolizeable energy of defatted rice bran and discount the price 20% under full-fat rice bran. Use in poultry in California is not so important.

D. Dewaxing Process at Tsumo.

Dr. J. Hunnel, Riviana reported that Tsumo collects rice bran from small mills within 8 hours of milling and experience FFA levels of 4 to 12%.

For dewaxing the crude rice bran oil, Tsumo adds about 15% hexane to the alkali refined oil to form a miscella which is filtered to remove waxes. While Dr. Hunnel did not provide details, the miscella was probably cooled and stored for a period before filtering. At a Taiwanese plant, a nylon mesh is used to filter the miscella. When the mesh becomes clogged with waxes, the miscella on top is decanted off and the nylon mesh is treated with super heated hexane to melt the wax away and regenerate the filter.

Dr. Hunnel noted that crude rice bran oil can be dewaxed by placing in a 15 to 20 foot high cylinder, allowing the waxes to settle to the bottom 2 or so feet in 7 days, and decanting off the dewaxed oil. Oil loss is significant (2/20 x 100 = 10% oil loss).

VI. STATUS IN TAIWAN

A. Stabilized Rice Bran Extraction.

Rice Bran Industries, Santa Monica, California has shipped containers of SRB to Taiwan for oil recovery. The limited known results have already been discussed under II. B. of this report on page 27.

B. Rice Bran Oil Production and Research.

The 1985 Annual Report of the Food Industry Research and Development Institute (FIRDI), Hsinchu, Taiwan estimated 15% or rice bran or 36,000 MT in Taiwan is processed for recovery of rice bran oil.

FIRDI has an objective to devise a new refining method to produce high quality oil from crude rice bran oil of high FFA content.

Pertinent accomplishments at FIRDI in 1985 are as follows: 1) Extrusion cooked rice bran yields oil which is much darker and more difficult to bleach than oil from unheated bran. 2) Crude oil extraction at 10 or 30°C versus 55°C produced a lighter color oil and the wax precipitation rate was faster. 3) Standard refining at FIRDI calls for degumming followed by alkali refining (17 Be caustic soda with 0.5% excess and 70°C) and washing (15% w/w; water/oil) the oil and bleaching. Wax was removed by adding 25% hexane to the bleached oil, cooling to 5°C with slow agitation, and filtering and hexane washing. Following desolventization, the oil was deodorized at 255°C at 2 Torr absolute vacuum and 4 Kg/hour stripping steam for 1.5 hours. The Active Oxygen Method (AOM) showed the rice oil stability at 13.5 hours compared to 11.0 for soybean oil. 4) Conventional alkali refining of degummed rice bran oil was compared to miscella (1:1; degummed oil:hexane) alkali refining. The miscella alkali refining gave a

5.3% higher refined oil yield and a lower FFA but darker color. 5) Rice milling/rice bran supply was evaluated in Taiwan in relation to the rice bran oil industry and recommendations were made for increasing the utilization of rice bran for oil recovery.

FIRDI could be a useful source of information.

VII. STATUS IN INDONESIA.

A. Rice Bran Stabilization at Klaten, Indonesia.

CLUSA has provided assistance to an Indonesian rice miller and feed formulator on rice bran stabilization. The company utilizes an InstaPro 2000 and a Brady extruder to stabilize 1,200 to 1,400 MT rice bran during the February to August rice milling season when rice bran is cheap. The SRB is used in feed formulations and is stored for sale in the September to January period when prices of rice bran can be at twice the level of those during the milling season.

A wear problem on the Brady rotor was encounter when the unit had a V-belt drive system which was corrected with the installation of a direct drive.

An evaluation of rice bran oil potential suggested it would not be economic.

VIII. LITERATURE

A. "Rice Bran, an Under-Utilized Raw Material". UNIDO. 1985.

This 251 page, 359 reference book describes various aspects of rice and rice milling that affect rice bran composition. It also reviews the technology of rice bran stabilization and storage aspects of rice bran and stabilized rice bran. The following paragraphs extract some pertinent information from the book.

Estimates for the Philippines indicate 3 to 5% of all rice is hand pounded; 40 to 45% is processed in single-pass huller mills (6,991 such mills) where hull and bran are removed together (kiskis; 5 to 8% fat content); and 45% is processed on two stage mills. In the two stage mills, de-husking is done by either a disc husker or a rubber roll husker. Whitening or rice bran (darak) removal is done on Cono mills (1,728 such mills; capacities 0.5 to 4.0 MT/hour). Rice bran removal rate was reported as 7% of paddy.

Disc huskers remove up to 2.5% of the bran and tend to dislodge a high percentage of the rice germ as well as removing the hulls. Rubber rolls remove very little bran and germ (up to 0.5%). Following dehusking, the mix of brown rice and hulls is sieved to remove "bran" and is then aspirated to remove hulls. The "bran" produced on disc huskers can have up to 10% fat content. "Bran" from the rubber roll huskers has less than 1% fat content. The brown rice with about 5% paddy is separated, the paddy being returned for dehusking and the brown rice is delivered to the whiteners. Cono mill whiteners using brown rice from disc huskers produce rice bran with a fat content of 15 to 17% while Cono mill whiteners using rice from rubber roll huskers produce rice bran with fat content of 18 to 20%.

Huskers normally process paddy at about 13% moisture and are set to remove about 95% of hulls in one pass. Separation of brown rice and paddy is necessary to remove the 5% paddy and recycle it to a second husker or back to the original husker. If this is not done, the rice bran will be contaminated with significant levels of hulls and the fat content will be reduced.

Friction-type whiteners (Engleberg) give higher fat content (18 to 20%) rice bran than abrasive whiteners (14 to 16% though up to 19% is not uncommon.)

Multistage whiteners result in higher fat content rice bran than single-pass single-cone whiteners because in the single pass single cone whiteners milling pressure must be great to remove all the bran in one pass. This pressure increases rice breakage and the exposed starch is abraded and contaminates the rice bran diluting the oil content. Also, the high pressure creates deep gouges into the rice kernel surface penetrating the starchy endosperm causing release of starch which dilutes the rice bran and its content of fat. Overloading or "pushing" the capacity of a rice mill increases the milling pressure and, for the reasons noted above, will increase the removal of starch and dilute the oil content of the rice bran.

A high level of brokens in the brown rice will obviously lead to a rice bran of reduced oil content because of starch contamination.

A common problem in rice mills is worn or torn screens in the whiteners that allow broken rice to enter the rice bran. Normally, not more than 5% of rice bran should be retain on a U.S. 20 mesh sieve (841 microns).

Holders normally [illegible] remove about 95% of [illegible] easily is [illegible] to re[illegible] [illegible] to back to the origina[illegible] [illegible] be [illegible] for [illegible]

[illegible]

[illegible]

A high level of [illegible] [illegible]

A common problem in [illegible] [illegible] [illegible]

Germs (lens shaped) are usually recovered by sieving bran on an 800 micron sieve/reel. The overs are then sieved on a 1,500 micron (US mesh 13) screen and the germs pass through and are collected while the overs are primarily small broken rice. The germ is usually contaminated with about 30% very small broken rice.

Germ represents 2 to 3% of the paddy. In lightly whitened brown rice (India), germ can represent 25% by weight of the rice bran produced. Germs have a high fat content (30%) and add to the oil content of the rice bran.

Varietal factors can greatly affect fat content of rice bran. One variety of rice in India was observed to have 4.2% fat compared with 1.2 to 2.0% normally seen. In some varieties, the germ "pops" off easily in other, they don't. Some varieties have more layers of oil rich aleurone cells. Germ as a percentage of kernel weight also varies significantly among varieties.

The FFA level increased at the rate of 0.75 to 1.0% per hour for the first 4-hours after milling and at the rate of 0.4 to 0.7% per hour for the next 24 hours. These figures suggest a 10 hour delay in stabilization would give a FFA level of 8.9% assuming the bran started at 2% FFA. A 24-hour delay would result in a FFA level of 16.6%

Heat treatment (especially dry) of rice bran darkens the color of extracted crude rice bran oil and may result in increased difficulty in bleaching.

Storage of stabilized rice bran and the measurement of FFA development is not a good indicator as to whether or not stabilization was complete. For example, SRB (autoclaved at 121°C for 2-hours and dried to 13.7% moisture) was stable for 34 days at 75.5% Relative Humidity (2.3 to 2.7% FFA) but at 80.3% Relative Humidity, moisture increased to 14.6% and there was mold growth (155,000/gram) after 27 days and FFA's had climbed to 18.1%. Even SRB stored at 11.5% moisture (68% RH) when inoculated with a low level of molds, developed increasing numbers of molds and after 20 days FFA's had climbed to 25.8%. The un-inoculated control was stable.

B. "Technical Advances in Rice Bran Oil Processing". Y. Takeshita. Transactions of the Kakushikan Univ. Dept. Engr. No. 5 1972 (Japan).

This 22 page document (review) describes the Japanese view of the rice bran oil industry which is well established in Japan, there being about 46 rice bran oil extraction plants (1972). Six are of the continuous design (immersion-type, Desmet-type, Rotocell-type) and 40 batch or battery extractors.

The older Sharples continuous alkali refining process was well used in Japan at an earlier time. The loss in the process was (1.0 to 1.1)(%FFA) (2). That process has been improved by the Lowloss Process, the Caustic Soda Ash Process, and the Alkali Miscella Refining Process. These improved processes result in 20 to 30% less loss during alkali refining than the old Sharples Process. See Figure V for a description of the Lowloss Process. Takeshita defines the refining loss as that amount loss from the extracted oil to the completion of neutralization and washing. The loss includes gums but not de-waxing.

FIGURE V

Sharples Lowloss Plant (Japan)

Open to air:

Crude Rice Bran Oil

↓

Treat with citric acid to condition gums; mix well.

↓

Neutralize at equivalence with 20° Bé caustic soda; mix, and centrifuge (AS-26 or SRG Separator)

→ Soap stock and gums

↓

Closed system:

Neutral oil is re-refined[1] by adding 32° Bé caustic soda; mix; and centrifuge.

→ Soap stock rich in the slightly acidic phenolic substance Oryzanol

↓

Neutral oil heated to 80° C and water washed; centrifuge (DF-2m; AS-16; or SRG and SSG)

Netural oil rewashed at 80°C with water; centrifuged (De Laval Separator).

↓

Twice washed oil is vacuum dried to 0.05% moisture to give high quality oil[3]

↓

Bleaching,
Dewaxing[3],
Deodorizing, and
Packaging as necessary and depending on use.

Common Oil; vacuum dry to 0.05% moisture[3]

↓

Bleaching,
Dewaxing[3]
Deodorizing, and
Packaging as necessary and depending on use.

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1. Re-refining makes bleaching easier or may eliminate the need to bleach.
2. Winterizing (dewaxing) is usually accomplished by adding hexane, cooling, centrifuging, and desolventizing.
3. Maximum Guaranteed Loss to this point = $(0.5 + 1.25W + W^2/80)\%$. W= Wesson loss.

According to Takeshita, Miscella Refining is the preferred process for rice bran oil in Japan. The process that starts with the miscella directly from the extractors consists of alkali refining, hot water washing, de-waxing, and stripping. Oil color is light and may not require bleaching. Of course the whole plant must be explosion proof. This process is particularly useful with oil of high FFA levels. In Japan, the average FFA level is 10%. As with the Sharples Lowloss Process, gums are removed with the soap stock.

The Sharples de-gumming process injects steam into the desolventized crude oil which is then centrifuged. Takeshita (1972) considers this process to be the most modern. Some 96% of gums are removed.

In describing the G.C. Cavanagh "Ranchers Miscella Refining Process" and the L.S. Crauer "American DeLaval Miscella Refining Process" (Booklet of American DeLaval Separator Company), Takeshita notes both are highly suited for rice bran oil processing though designed for cottonseed oils. In the Ranchers process, waxes are removed from cooled miscella (after neutralization and washing) by centrifugation. Takeshita reports the yield loss at this de-waxing step was less than 10%.

Rice bran oil contains 1 to 2% phenolic compounds like Oryzanol of high boiling point and which remain in the oil even after deodorization. These are weakly acidic and result in the oil showing 0.1% FFA by phenolphthalein. The use of the indicator Alkaliblue-6B shows that the true level of FFA's is 0.03% and the 0.07% difference is due to the phenolics. This has importance in the smoke point. Oil with 0.1% FFA's has a smoke point of 380°F while 0.03% FFA's gives a smoke point well above 400°F.

In India, almost all rice bran oil mills operate Desmet or Lurgi continuous extractors.

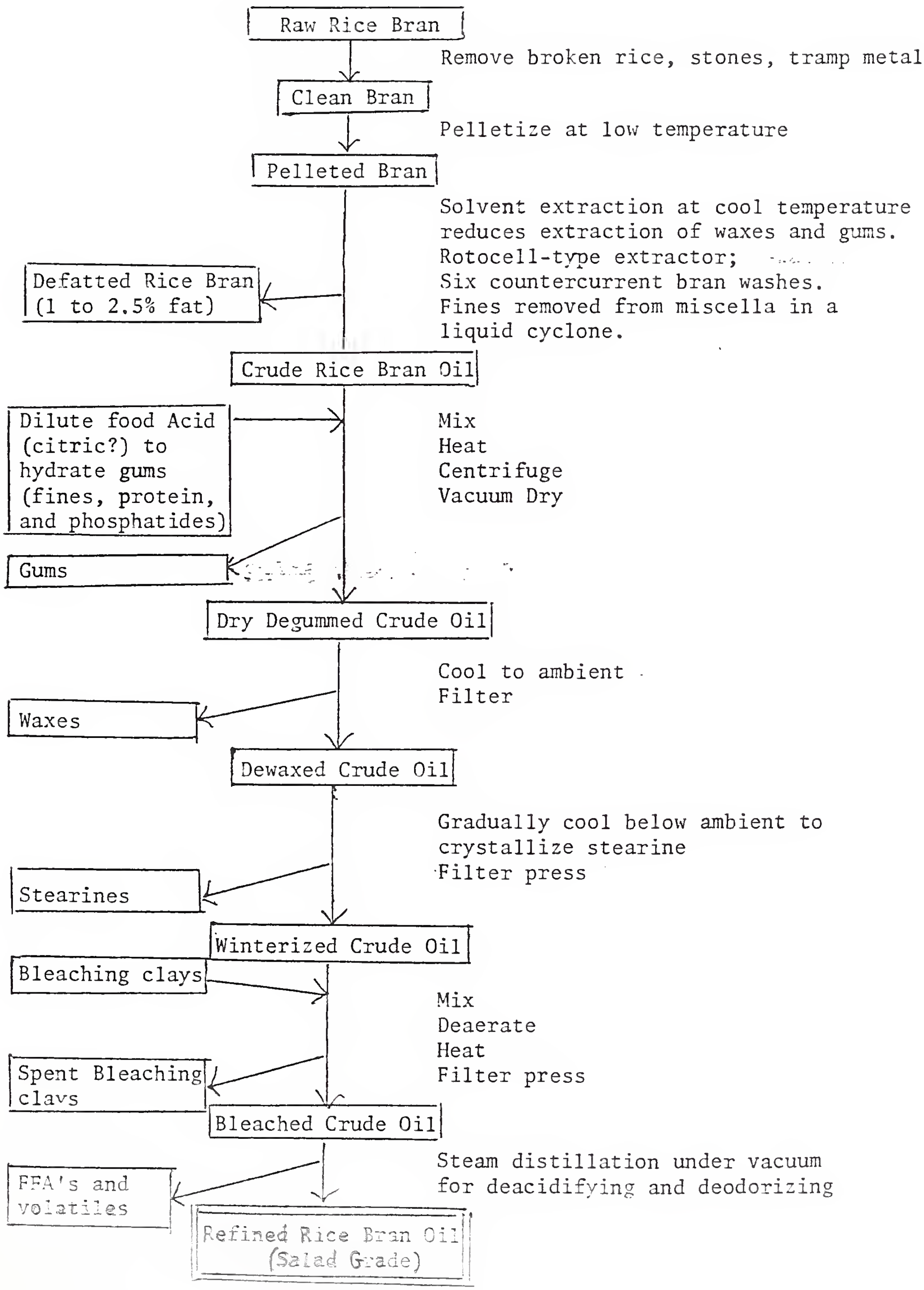
Percolation rates of hexane in solvent extraction are impeded at higher moisture levels and thus 5% moisture is preferred. Drying is considered an important pretreatment of rice bran (after agglomeration with steam) in Japan.

C. "RICE BRAN OIL PLANT" - Yoshino. 1982.

This is a commercial bulletin put out by Yoshino, Osaka, Japan describing their low temperature, Rotocell-type rice bran extraction process and "Physical" refining plant (for sale). Physical refining refers to removal of FFA's by steam distillation under vacuum. Recovered FFA's can be purified by re-distillation and then esterified (with glycerol) to produce more crude oil. The yield of refined oil (without esterification of FFA's) is better than that achieved with the alkali miscella refining process--the best available up to 1982. Figure VI provides an outline of the process.

FIGURE VI

Low Temperature Extraction and Physical Refining Process for Rice Bran Oil. Yoshino, Osaka, Japan. 1982.



RICE BRAN STABILIZER
EXECUTIVE SUMMARY
1/16/87

ANNEX I

I. Technical Aspects

A. PRODUCTION DATA

1. STABILIZATION OF RICE BRAN AT CABANATUAN BY NFA.

a. Rated capacity of rice bran stabilizer is 450 Kg per hour.
b. Operations are to be 10 hours per day, 22 days per month
c. Operating efficiency is projected at 80%
d. Recovery of stabilized bran is 92.5% of raw bran
e Procurement cost of rice bran is: P 2.0/Kg.
f. Private sector bran is used. It will average 15.0% fat content, as is.

2. EXTRACTION

a. Universal Robina Corporation, Bagong Ilog, Pasig, Metro Manila.
b. Estimated extraction capacity is 70 MT/day; Lurgi type.
c. Delivery of stabilized bran shall be made every quarter.
d. Recovery rate of crude oil shall be 12.0% of stabilized bran.
e. Crude oil shall average 10.0% free fatty acids.

3. REFINING

a. Recovery rate of refined oil from crude oil is 50.0%
b. CENAPRO, Mandaue, Cebu City
c. Estimated crude oil refining capacity is 25 MT/day.
d. Total production of refined oil per year is 52.7 MT or 3.103 five-gallon tins.

II. Financial Aspects

A. TOTAL PROJECT COST

The project requires an initial investment of P 1,744,815 for the purchase/acquistion of the project's various fixed and current assets to be distributed as follows:

First quarter	-	P 734,894
Second quarter	-	900,017
Third quarter	-	54,952
Fourth quarter	-	54,952
Total		1,744,815

B. BUDGET REQUIREMENT

Budget requirement for the project is P 3,727,504 broken down as follows:

Capital Expenditures			
Installation Cost	0	(P 80,000 already paid)	
Oil Tanks (24)	128,640		₱ 128,640

Revenue Expenditures

Procurement Cost (Bran)	P 1,939,080	
Stabilization Cost	485,936	
Extraction Cost	622,936	
Refining Cost	447,004	
Packaging Cost	75,092	
Dispersal Cost	21,348	
Distribution Cost	7,448	P 3,598,864
Total		P 3,727,504

C. PRODUCTION COST

Estimated production cost per five-gallon tin (17 KG) is P 702.52 Details are as follows:

	Amount	Percent
Procurement of raw materials	P 126.27	18.0
Stabilization Cost	156.60	22.3
Extraction Cost	200.76	28.6
Refining Cost	153.73	21.9
Packaging Cost	24.20	3.4
Dispersal Cost	6.88	1.0
Distribution Cost	2.40	0.3
Overheads	31.68	4.5
Total	702.52	100.0

D. PROFITABILITY (LOSS)

Based on the current selling price of P 600 per five-gallon tin, the computed net profit (loss) is: P (102.52) per five-gallon tin.

E. RETURN ON INVESTMENT (ROI)

Computed ROI is less than 0%

F. PAYBACK PERIOD

The initial investment of P 1,744,815 will not be paid back in total.

PRODUCTION SCHEDULE

1. BRAN STABILIZED

	ANNUAL
Annual raw bran requirement (79.2 MT/MO)	950.4 MT
Recovery from stabilization	92.5 %
Stabilized Bran -	879.12 MT

2. CRUDE OIL RECOVERED

Stabilized Rice Bran for Extraction (73.26 MT/MO)	879.12 MT
Extraction rate	12.0 %
Crude oil recovered (8.7912 MT/MO) - - - - - - - - - -	105.4944 MT

3. DEFATTED RICE BRAN RECOVERED

Stabilized bran for extraction (73.26 MT/MO)	879.12 MT
Less crude oil recovered (8.7912 MT/MO)	105.4944 MT
Defatted rice bran recovered (64.4688 MT/MO) - - - -	773.6256 MT

4. REFINED OIL RECOVERED

Crude Oil Recovered (8.7912 MT/MO)	105.4944 MT
Refining rate	50.0 %
Refined oil recovered (4.3956 MT/MO) or - - - - - - - - 258.6 five-gallon tins per month.	52.7472 MT or 3,103 five-gallon tins

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END OF EXECUTIVE SUMMARY

RICE BRAN STABILIZATION PROJECT

REVISION OF NOVEMBER 1984 NFA ESTIMATE[10]
David A. Fellers
1/16/87

FINANCIAL ASSUMPTIONS

I. Revenues (Exhibit I)

Sales from refined oil is the main source of revenue while sales from defatted rice bran will give additional income. No income is expected from acid oil or waxes. A five-gallon tin of refined oil will be sold at P 600 (P 120/gallon). Defatted rice bran is sold at the same price as raw rice bran or P 2.0/Kg.

II Cost and Expenses

1. Installation cost for stabilizer

Cost (P 80,000) to install has already been paid .

2. Other Equipment

The project will will acquire 24 crude oil tanks to be used in transporting crude oil to the refinery. Estimated cost per tank is P 5,360.

3. Procurement cost of rice bran (Schedule II)

P 2.0/Kg

4. Stabilization cost (Schedule III)

Stabilization expense includes salaries of one supervisor and one quality control technician which is equilvalent to 25% of their salaries as regular NFA employees. One operator and 4 job orders shall be hired at rates of P 9.82/hour and P 4.26/hour (each) respectively.

Other stabilization expenses are electricity which is computed at P 1.49/kw-hr.; maintenance cost estimated at P 80.0/MT input; and, empty sacks will cost P 5.96/piece.

Installation cost of P 80,000 will be amortized over 10 years at P 8,000/year.

5. Extraction Cost (Schedule IV)

Extraction fee is based on NFA's 1984 cost for extraction at Tacurong plus 6% inflation for each of three years since then or P 590/MT input. Extraction fee is paid to Universal Robina. Other extraction costs include trucking and handling expenses from NFA/Cabanatuan to URC/Manila and depreciation cost of oil tanks over 7 years.

6. Refining Cost (Schedule V)

Refining fee is based on CENAPRO's 1984 charge of P 6,600/MT refined oil produced plus 6% for inflation for each of three years since or P 7860/MT refined oil.

Refining costs include trucking, loading/unloading, handling, and ocean freight.

7. Packaging Cost (Schedule VI)

Packaging cost includes cost of tins which is P 20/five-gallon tin. Transportation cost of tins is estimated at P 4.2/tin.

8. Dispersal Cost to Manila

Dispersal cost is the cost of finished product from the refinery at Cebu City to Manila warehouse. This includes ocean freight which is estimated at P 6.4/five-gallon tin and handling cost which is estimated at P 0.48/can/move.

9. Distribution Expenses

Handling cost is estimated at P 0.6/move/can. Trucking cost is P 1.2/can.

RICE OIL STABILIZATION/EXTRACTION/REFINING PROJECT

PROJECTED INCOME STATEMENT FOR ONE (1) YEAR

SALES (SCHEDULE I)			P 1,861,800
LESS: COST OF SALES			
Procurement Cost of Rice Bran	P 1,939,080		
Less: Proceeds of sales from Defatted Bran	1,547,252		
		%	
Net Procurement Cost	391,828	18.8	
Stabilization Cost (Sch III)	485,936	23.4	
Extraction Cost (Sch IV)	622,956	29.9	
Refining Cost (Sch V)	477,004	22.9	
Packaging Cost (Sch VI)	75,093	3.6	
Dispersal Cost (Sch VII)	21,348	1.0	
Distribution Cost (Sch VIII)	7,448	0.4	
Total Cost Before Overhead	2,081,613	100.0	
Add: Overhead Cost (4.723% of total cost before overhead	98,315		
TOTAL COST			P 2,179,928
NET PROFIT (LOSS)			(318,128)
Estimated Production Cost with Overhead Per Five-Gallon Tin (P 2,179,928 ÷ 3,103)			702.52
Current selling price per Five-Gallon Tin			600.00
Net Profit (loss) per Five-Gallon Tin			(102.52)

RICE BRAN STABILIZATION PROJECT

PROJECTED CASH FLOW STATEMENT

	1st Year				Sub-	2nd Year		Sub-	Grand
	1st Q	2nd Q	3rd Q	4th Q	Total	1st Q	2nd Q	Total	Total
Cash Balance Beginning	0	0	0	0	0	0	551,302	0	0
Add: Cash Inflows									
Sales (Sch I)	0	0	852,264	852,264	1,704,528	852,264	852,264	1,704,528	3,409,056
Investment	734,894	900,017	54,952	54,952	1,744,815	0	0	0	1,744,815
Total Cash Inflows	734,894	900,017	907,216	907,216	3,449,343	852,264	852,264	1,704,528	5,153,871
Less Cash Outflows									
Capital Expenditures									
Installation Cost	0	0	0	0	0	0	0	0	0
Acquisition oil tanks	128,640	0	0	0	128,640	0	0	0	128,640
Sub-Total	128,640	0	0	0	128,640	0	0	0	128,640
Revenue Expenditure									
Procurement	484,770	484,770	484,770	484,770	1,939,080	0	0	0	1,939,080
Stabilization	121,484	121,484	121,484	121,484	485,936	0	0	0	485,936
Extraction	0	155,739	155,739	155,739	467,217	155,739	0	155,739	622,956
Refining	0	119,251	119,251	119,251	357,753	119,251	0	119,251	477,004
Packaging	0	18,773	18,773	18,773	56,319	18,773	0	18,773	75,092
Dispersal Cost	0	0	5,337	5,337	10,674	5,337	5,337	10,674	21,348
Distribution Expenses	0	0	1,862	1,862	3,724	1,862	1,862	3,724	7,448
Sub-Total	606,254	900,017	907,216	907,216	3,320,703	300,962	7,199	308,161	3,628,864
Total Cash Outflows	734,894	900,017	907,216	907,216	3,449,343	300,962	7,199	308,161	3,757,504
Cash Balance End	0	0	0	0	0	551,302	1,396,367	1,396,367	1,396,367
								Total Investment	1,744,815
								Net Profit (Loss)	(348,448)

SCHEDULE I

SALES

			2nd Year		
RICE OIL	3rd Q	4th Q	1st Q	2nd Q	Per Year
Total Production (5-gal tins)	775.75	775.75	775.75	775.75	3103
Estimated Selling Price per 5-gal tin	P x600	x600	x600	x600	x600
	P 465,450	465,450	465,450	465,450	1,861,800

DEFATTED RICE BRAN	1st Q	2nd Q	3rd Q	4th Q	Per Year
Total Defatted Bran (Kgs)	193,406.5	193,406.5	193,406.5	193,406.5	773,626
Selling Price per Kg	P x2.0	x2.0	x2.0	x2.0	x2.0
	P 386,813	386,813	386,813	386,813	1,547,252
TOTAL	P 852,263	852,263	852,263	852,263	3,409,052

SCHEDULE II

PROCUREMENT COST OF RAW BRAN

		1st Q	2nd Q	3rd Q	4th Q	Per Year
Raw Bran Requirement, Kgs		237,600	237,600	237,600	237,600	950,400
Buying Price of Raw Bran		P x2.0	x2.0	x2.0	x2.0	x2.0
Cost of Raw Rice Bran	P	475,200	475,200	475,200	475,200	1,900,800
Add: Hauling Cost						
1) Trucking						
(30 Kms)(P 9.27/Hr)(66 days) / 5 KM/Hr		3,868	3,868	3,868	3,868	15,476
2) Handling						
3 moves at P 0.28/move per 35 Kg bag		5,702	5,702	5,702	5,702	22,808
Total Hauling Cost	P	9,570	9,570	9,570	9,570	38,280
Total Procurement Cost	P	484,770	484,770	484,770	484,770	1,939,080

SCHEDULE III

STABILIZATION COST

	PER MONTH		PER YEAR	
I. Salaries and Wages				
1 Supervisor at P 3,728/MO x 25%	P 932		11,184	
1 Operator at P 9.82/Hr x 10 Hrs/Day x 22 days	2,160		25,920	
4 Laborers at P 4.26/Hr each	3,749		44,986	
1 Quality Control Technician at P 2,827/MO x 25%	707	7,548	8,482	90,577
II. Electricity				
$\frac{8,360 \text{ Kw-Hr}}{\text{MO}} \times \frac{\text{P } 1.49}{\text{KW-Hr}}$	12,456		149,472	
III. Maintenance				
P 80.0/MT input	6,336		76,032	
IV. Depreciation				
P 80,000 over ten years	667		8,000	
V. Containers/Bags				
P 5.96/empty sack; 2,263 bags/MO	13,487		161,850	
TOTAL STABILIZATION COST	P 40,494		485,936	

SCHEDULE IV

EXTRACTION COST

		PER QUARTER	PER YEAR
I. Extraction Fee[1]			
Stabilized Bran for Extraction, MT		219.78	879.12
Extraction Fee per MT input, P		x 590	x 590
Total Extraction Fee	P	129,670	518,681
II. Trucking (Cab.-Pasig 250 KMS Roundtrip)			
P 42/MT		9,231	36,922
III. Handling (5 moves)			
P 0.39/bag x 5 moves x 6,788 bags/Q		12,244	48,976
IV. Depreciation			
24 Oil Tanks at P 5,360 each; 7 years		4,594	18,377
TOTAL EXTRACTION COST		155,739	622,956

1. Based on NFA Tacurong Costs in July 1984 plus 6% inflation for each of three years is P 590/MT input

SCHEDULE V

REFINING COST

		Per QUARTER	PER YEAR
I. Refining Fee			
	(26.37 MT Crude oil) (50%) (P 7860/MT Output)	P 103,634	414,536
II. Trucking			
	Pasig to Manila Pier (12 KM rd. Trip) 26.37 MT/Q x (P 0.58/MT/KM) x 12 KM	184	734
	Cebu Pier to refinery (crude oil) 26.37 MT/Q x P 31.0/MT	817	3,270
	Refinery to Cebu Pier (empty tanks) 24 tanks/Q x P 31.0	744	2,976
III. Unloading from truck at Manila pier (crude Oil)	P 11.9 x 26.37 MT/Q	313	1,252
	Loading truck at Cebu pier (crude oil) P 11.9 x 26.37 MT/Q	313	1,252
	Unloading from Truck at Cebu pier (empty tanks) P 6.0 x 24 tanks/Q	144	576
	Loading Truck at Manila pier (empty tanks) P 6.0 x 24 tanks/Q	144	576
IV. Handling			
	At Manila pier (crude oil) P 25.7 x 26.37 MT/Q	678	2,711
	At Cebu Pier (Crude Oil) P 25.7 x 26.37 MT/Q	678	2,711
	At Cebu Pier (empty tanks) P 12.9/tank x 24 tanks/Q	310	1,238
	At Manila Pier (empty tanks) P 12.9/tank x 24 tanks/Q	310	1,238
V. Freight			
	Manila to Cebu (crude Oil) P 320/MT x 26.37 MT	8,438	33,754
	Cebu to Manila (empty tanks) P 10 6/tank x 24 tanks/Q	2,544	10,176
	TOTAL REFINING COST	P 119,251	477,004

SCHEDULE VI
PACKAGING COST

Packaging Materials	PER QUARTER	PER YEAR
1) Tin Cans for 52.747 MT Refined Oil 3,103 five-gallon tins x P 20/Tin can	P 15,515	62,060
2) Transportation of Paging Materials P 4.2/Tin x 3,103 Tins	3,258	13,033
TOTAL PACKAGING COSTS	18,773	75,093

SCHEDULE VII
DISPERSAL COST TO MANILA

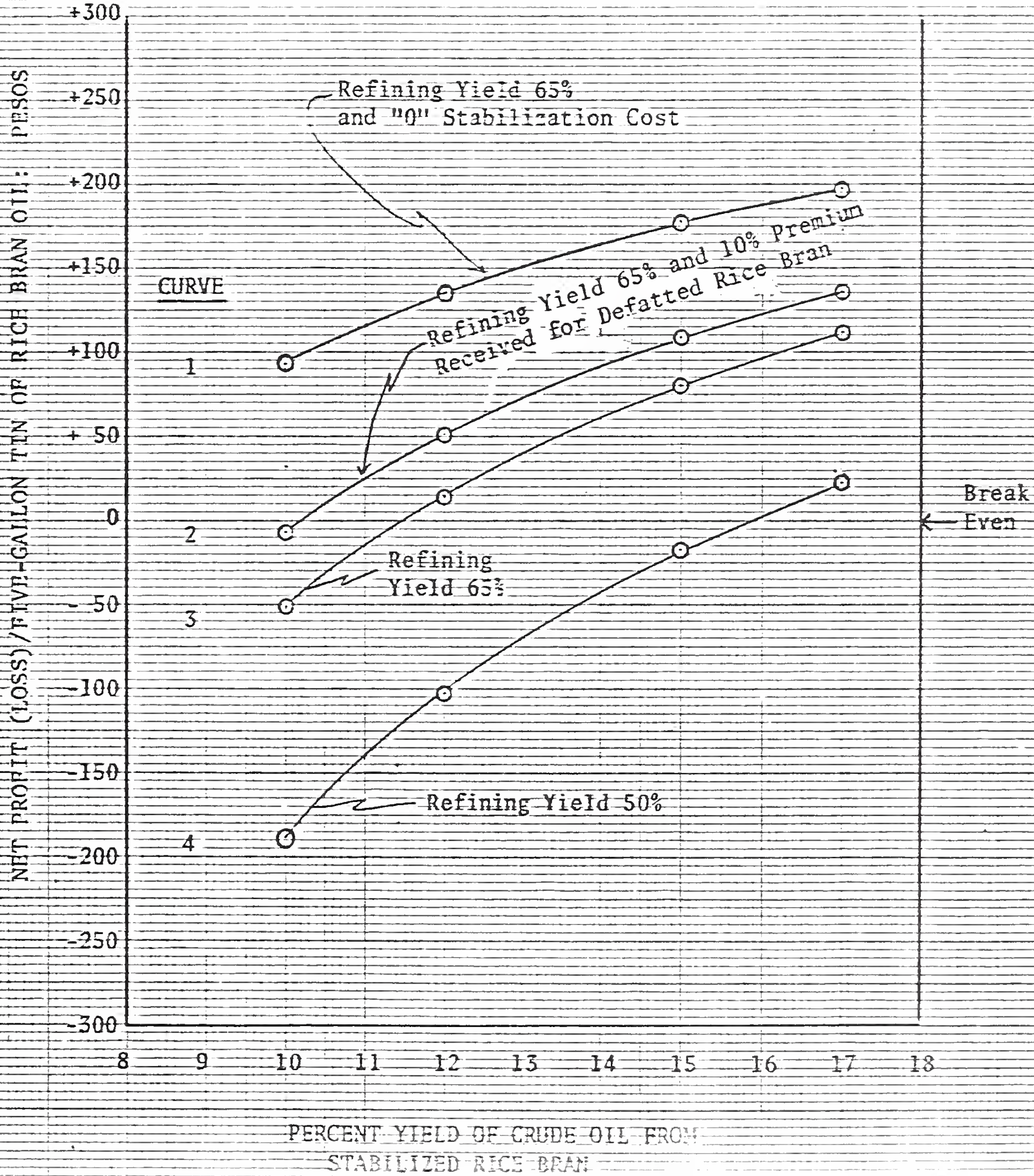
I. Freight		
3,103 five-gallon tins at P 6.4/Tin	4,965	19,859
II. Handling		
3,103 Tins at P 0.48.Tin	372	1,489
TOTAL DISPERSAL COST	5,337	21,348

SCHEDULE VIII
DISTRIBUTION EXPENSES

I. Handling (2 moves at P 0.6/Tin)	931	3,724
II. Trucking Cost. P 1.2/Tin x 3,103 Tin/Year	931	3,724
TOTAL DISTRIBUTION COST	1,862	7,448

FIGURE 1

Effect of Various Factors on Profitability of Rice Bran Oil Recovery and Sale. Market Price of Rice Bran Oil is Taken at P 600 ($US30) Per Five Gallon Tin.



CALCULATIONS FOR FIGURE I

REFINING YIELD 65%

	% Yield of Crude Oil			
	10	12	15	17
Crude Oil, KG	87,912.0	105,494.4	131,868.0	149,450.4
Refined Oil, KG	57,142.8	68,571.4	85,714.2	97,142.8
# Five-Gallon Tins of Oil	3,361.3	4,033.6	5,042.0	5,714.3
Sales of Oil; P 600/five-Gal	2,016,960	2,420,160	3,025,200	3,428,580
Purchase of raw bran; P 2/KG	1,939,080	1,939,080	1,939,080	1,939,080
Sales Defatted Bran; P 2/KG	1,582,416	1,547,252	1,494,504	1,459,340
Procurement Cost of Bran Net	356,664	391,828	444,576	479,740
Stabilization Cost	485,936	485,936	485,936	485,936
Extraction Cost	619,893	622,956	627,550	630,614
Refining Cost	516,691	620,057	775,084	878,403
Packaging Cost	81,341	97,613	122,019	138,284
Dispersal Cost	23,126	27,752	34,691	39,317
Distribution Cost	8,068	9,682	12,102	13,715
Production Cost	2,091,719	2,255,824	2,501,958	2,666,009
Overhead	98,792	106,543	118,167	125,916
Total Cost	2,190,511	2,362,367	2,620,125	2,791,925
Profit (Loss)	(173,551)	57,793	405,075	636,655
Profit. (Loss)/Five-Gallons oil	(51.6)	14.3	80.3	111.4

REFINING YIELD 50%

Crude Oil, KG	87,912.0	105,494.4	131,868.0	149,450.4
Refined oil, KG	43,956.0	52,747.2	65,934.0	74,725.2
# Five-Gallon Tins of Oil	2,585.6	3,103.0	3,878.5	4,395.6
Sales of Oil; P 600/Five-Gal	1,551,360	1,861,800	2,327,250	2,637,360
Purchase of raw bran; P 2/KG	1,939,080	1,939,080	1,939,080	1,939,080
Sales Defatted Bran; P 2/KG	1,582,416	1,547,252	1,494,504	1,459,340
Procurement Cost of Bran Net	356,664	391,828	444,576	479,740
Stabilization Cost	485,936	485,936	485,936	485,936
Extraction Cost	619,893	622,956	627,550	630,614
Refining Cost	397,487	477,004	596,255	675,724
Packaging Cost	62,575	75,093	93,866	106,377
Dispersal Cost	17,783	21,348	26,685	30,244
Distribution Cost	6,206	7,448	9,310	10,551
Production Cost	1,946,544	2,081,613	2,284,178	2,419,186
Overhead; 4.723%	91,935	98,315	107,882	114,258
Total Cost	2,038,479	2,179,928	2,392,060	2,533,444
Profit (Loss)	(487,119)	(318,128)	(64,810)	103,916
Profit (Loss)/Five-Gallons Oil	(188.4)	(102.5)	(16.7)	23.6

1984 Costs for Comparison

REFINING YIELD 65%

	% Yield of Crude Oil			
	10	12	15	17
Crude Oil, KG	87,912.0	105,494.4	131,868.0	149,450.4
Refined Oil, KG	57,142.8	68,571.4	85,714.2	97,142.8
# Five-Gallon Tins of Oil	3,361.3	4,033.6	5,042.0	5,714.3
Sales of Oil; P 600/five-Gal	2,016,960	2,420,160	3,025,200	3,428,580
Purchase of raw bran; P 2/KG	1,933,337	1,933,337	1,933,337	1,933,337
Sales Defatted Bran; P 2/KG	1,582,416	1,547,252	1,494,504	1,459,340
Procurement Cost of Bran Net	350,921	386,085	438,883	473,740
Stabilization Cost	421,256	421,256	421,256	421,256
Extraction Cost	520,219	522,791	526,648	529,220
Refining Cost	433,949	520,755	650,944	737,750
Packaging Cost	72,271	86,728	108,410	122,867
Dispersal Cost	19,160	22,993	28,741	32,574
Distribution Cost	8,068	9,682	12,102	13,715
Production Cost	1,825,844	1,970,290	2,186,934	2,331,122
Overhead	86,235	93,057	103,289	110,099
Total Cost	1,912,079	2,063,347	2,290,223	2,441,221
Profit (Loss)	104,881	356,813	734,977	987,359
Profit (Loss)/Five-Gallons oil	31.2	88.5	145.8	172.8

REFINING YIELD 50%

	10	12	15	17
Crude Oil, KG	87,912.0	105,494.4	131,868.0	149,450.4
Refined oil, KG	43,956.0	52,747.2	65,934.0	74,725.2
# Five-Gallon Tins of Oil	2,585.6	3,103.0	3,878.5	4,395.6
Sales of Oil; P 600/Five-Gal	1,551,360	1,861,800	2,327,250	2,637,360
Purchase of raw bran; P 2/KG	1,933,337	1,933,337	1,933,337	1,933,337
Sales Defatted Bran; P 2/KG	1,582,416	1,547,252	1,494,504	1,459,340
Procurement Cost of Bran Net	350,921	386,085	438,833	473,740
Stabilization Cost	421,256	421,256	421,256	421,256
Extraction Cost	520,219	522,791	526,648	529,220
Refining Cost	333,804	400,581	500,726	567,463
Packaging Cost	55,592	66,714	83,393	94,514
Dispersal Cost	14,739	17,687	22,109	25,057
Distribution Cost	6,206	7,448	9,310	10,551
Production Cost	1,703,586	1,800,419	2,002,275	2,121,801
Overhead; 4.723%	80,460	85,034	94,567	100,213
Total Cost	1,784,046	1,885,453	2,096,842	2,222,014
Profit (Loss)	(232,686)	(23,653)	230,408	415,346
Profit (Loss)/Five-Gallons Oil	(90.0)	(7.6)	59.4	94.5

CONSIDERATIONS FOR IMPROVING THE ECONOMICS OF RICE BRAN STABILIZATION AND OIL RECOVERY

1. Get a higher price for refined oil.

   a) A major impediment to this approach has been the poor quality of rice bran oil produced in the Philippines (NFA Tacurong experience). A better quality oil might compete directly with corn and soy oils which sell at up to P 750/five-gallons compared to the P 600 for rice bran oil.

   b) Export crude rice bran oil to a country with an established rice bran oil refining industry that produces a high quality oil.

2. Get a premium for defatted rice bran.

   Some hog feed millers in the Philippines have utilized the level of protein in a feed material in establishing its value. This suggests that defatted rice bran, which has a higher protein content than full-fat rice bran, might be able to command a premium. Defatted rice bran has been successfully sold in limited quantities at a 10 to 15% premium at Tacurong by selling it during the off-milling season when regular full-fat rice bran is scarce.

3. Get a return for acid oil and waxes.

   This option requires an up-graded rice bran oil refinery as does item "1" above.

4. Reduce extraction costs

   a) Reduce hexane loss below 12 liters/MT stabilized rice bran processed.

   b) Maintenance, insurance and depreciation expense levels at NFA Tacurong are based on operations at only 46.6% of capacity, These cost, which have been used in this estimate, may be less for Universal Robina.

   c) Note, however, that the extraction fee used in this estimate doesn't include any profit margin for Universal Robina.

5. Reduce refining costs.

   While NFA has substantial experience in contracting rice bran oil refining at CENAPRO and RICOR at Cebu City, US Consultant, George Kopas felt their quoted refining fees were "very high". A fee based on crude oil to be refined rather than refined oil produced would remove some risk for the refiner and could be the basis for negotiating a lower refining fee.

6. Utilize only private sector bran of high fat content.

   It appears that CONO-type mills produce bran of higher fat content than NFA owned and operated Satake Rice Mills.

7. Reduce Stabilization Costs.

   a) Recover value for sacks used in bran collection/handling and storage.

   b) Install a larger extruder such that labor requirements are not increased but production is.

8. The use of 6% inflation for each of 3 years to adjust costs maybe inappropriate.

CONSIDERATIONS FOR IMPROVING THE ECONOMICS OF
RICE BRAN STABILIZATION AND OIL RECOVERY

1. Get a higher price for refined oil.

a) A major impediment to this approach has been the poor quality of [illegible]
Bran oil produced in the Philippines from Tanzania extractors. A [illegible]
quality oil might compete directly with more and coconut oils which [illegible]
at up to ₱ 750/Drum-gallons compared to the ₱ [illegible]

b) Export crude. Rice bran oil to a country with a [illegible]
oil refining industry that produces a high [illegible]

2. Get a premium for delivered rice/bran

Some long term millers in the Philippines [illegible]
to a Fund potential in stabilizing [illegible]
rice bran, which has a higher protein [illegible]
be able to command a premium. Hopefully [illegible]
in limited quantities [illegible]
during the effecting season when [illegible]

3. Get a return for rice oil for rates

This will require [illegible]
item [illegible] above.

4. Reduce [illegible] costs

a) Reduce license [illegible]

b) [illegible]
are based on operations [illegible]
have been used in this approach [illegible]

c) Note, however, that the assumption [illegible]
any profit margin for [illegible]

5. Reduce refining costs

While NFA [illegible] experience in [illegible]
at CERAPRO and [illegible]
quoted refining fees were "very high". A [illegible]
refined rather than refined oil produced [illegible]
refiners and could be the basis for [illegible]

6. Utilize only private [illegible]

It appears that [illegible]
than NFA owned and operated [illegible]

7. Reduce Stabilization Costs

a) Recover value for [illegible]

b) Install a larger extruder [illegible]
but production [illegible]

RICE BRAN STABILITY EXPERIMENT

NFA/CABANATUAN JUNE 11, 1985

PURPOSE :

Evaluate processing temperatures of 250 to 280 °F in 5 °F increments on stability of rice bran.

EXPECTED RESULTS:

Catalase foam test will give immediate indication of stability at various processing temperatures. Free Fatty Acid (FFA) analyses run over three months will provide verification of catalase test and allow selection of the appropriate processing temperature to stabile rice bran under conditions at NFA/Cabanatuan.

PROCEDURE:

The NFA/Cabanatuan Satake is operated at half capacity (4.5 MT/hour) producing 400 KG rice bran per hou. After accumulating rice bran for 45 minutes in the live surge, start up Brady (chrome plated rotor with about 20 operational hours). Record temperature every minute from Brady and Surface thermometers for entire run. Bring temperature to 280 °F using the surface thermometer. Turn on water at a flow setting of 3.0 which is the equivalent of adding 1.0% water to the rice bran. Continue to operate the Brady to get a constant 280 °F. Once a constant 280 °F is achieved, run for 7 minutes and then collect 2 sacks of stabilized rice bran from the end of the cooler insuring that all previous bran had been cleaned out of the packing suge. Two sack is about 70 KG. During collection of the two sacks, take four 300-400 gram samples from the end of the coolerand place in plastic bags. Label the bags: SRB-280-1, SRB-280-2, SRB-280-3,and SRB-280-4. Label the 2 sacks: SRB-280-1 (JUNE 11, 1985) and SRB-280-2 (JUNE 11, 1985). Drop extruder temperature to 275 °F and continue to run to obtain steady operation. Once steady, continue to run for 7 minutes and then collect 2 sacks of 275 °F SRB. Also collect four 300-400 gram samples and place in plastic bags. Label as for previous samples except substitute 275 for 280. Repeat at temperatures of 270, 265, 260, 255 and 250 °F.

DATE TO ANALYZE	TIME LAPSE	ANALYTICAL METHOD AND AND SAMPLES TO ANALYZE		TOTAL SAMPLES TO ANALYZE
6/11-12	0-1 day	FFA, 1 sample/temperature	use plastic bag samples	7
		Particle size, 2 samples/temperature		14
		Catalase foam, 4 samples/temperature		28
		Moisture, 2 samples/temperature		14
		Crude Fat, 2 samples		2
6/25	2 weeks	FFA, each sack in Warehouse		14
		Catalase, each sack in warehouse		14
7/9	4 weeks	FFA, each sack in warehouse		14
7/23	6 weeks	FFA, each sack in warehouse		14
8/13	2 months	FFA, each sack in warehouse		14
9/10	3 months	FFA, each sack in warehouse		14
		Catalase, each in warehouse		14
		Moisture, each sack in warehouse		14

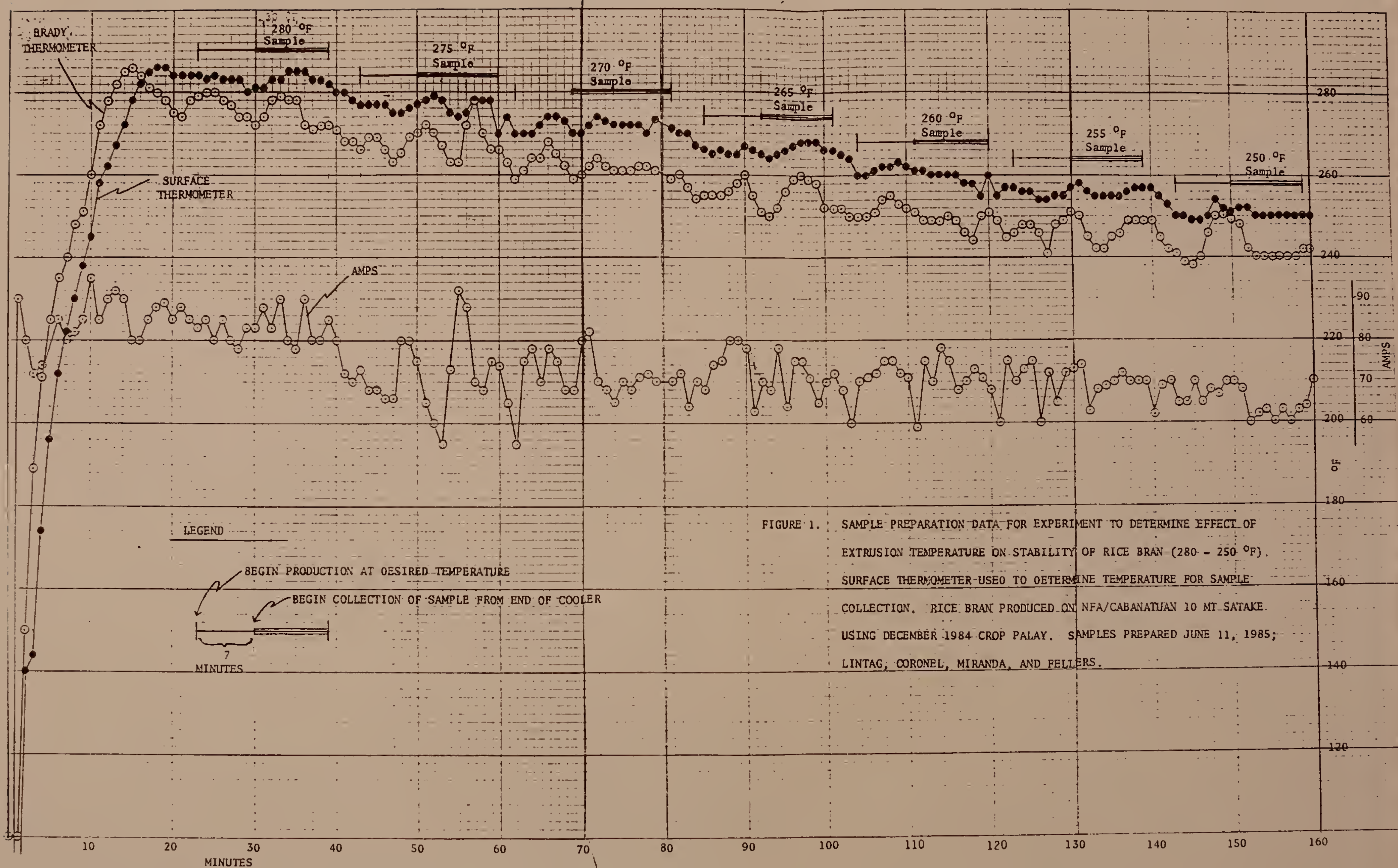


FIGURE 1. SAMPLE PREPARATION DATA FOR EXPERIMENT TO DETERMINE EFFECT OF EXTRUSION TEMPERATURE ON STABILITY OF RICE BRAN (280 - 250 °F). SURFACE THERMOMETER USED TO DETERMINE TEMPERATURE FOR SAMPLE COLLECTION. RICE BRAN PRODUCED ON NFA/CABANATUAN 10 MT SATAKE USING DECEMBER 1984 CROP PALAY. SAMPLES PREPARED JUNE 11, 1985; LINTAG, CORONEL, MIRANDA, AND FELLERS.

RESULTS - RICE BRAN STABILITY EXPERIMENT

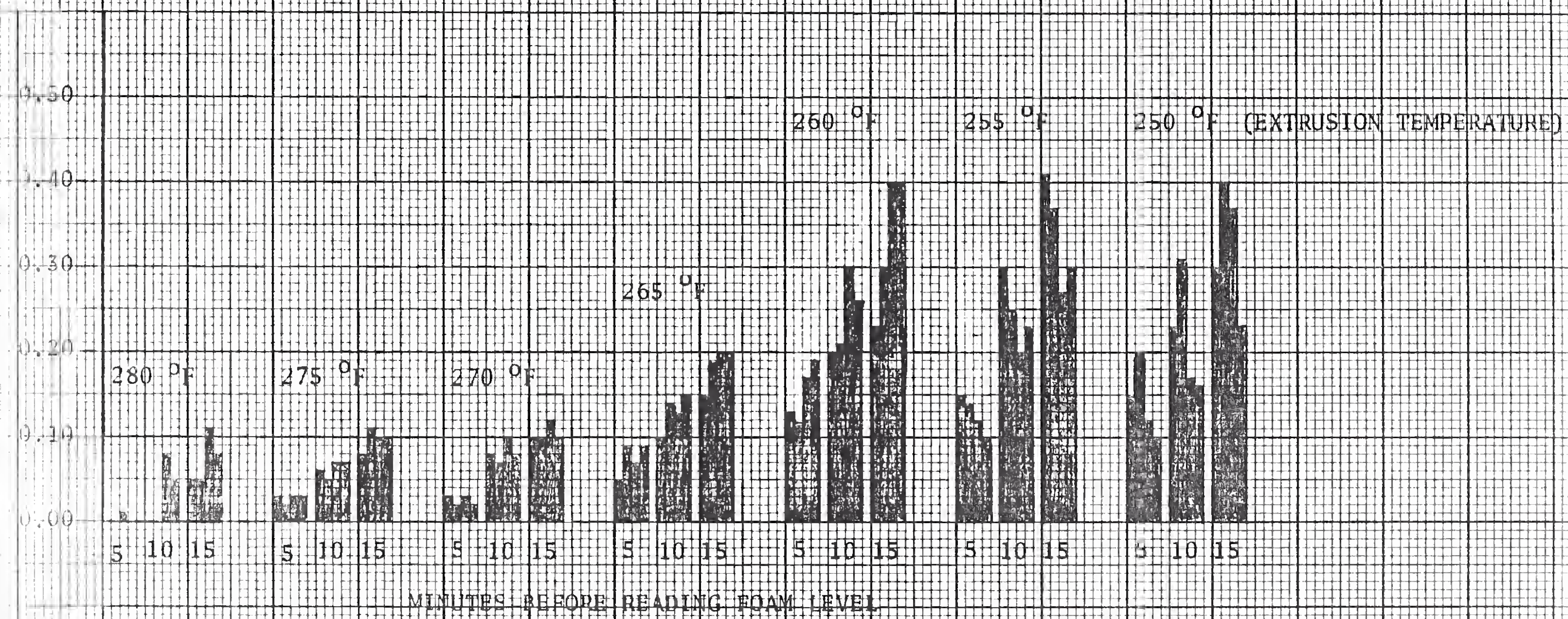
SAMPLE	MOISTURE[2] 0 TIME	MOISTURE[2] 3 MONTHS	PARTICLE SIZE[1] % INTERMED. 0 TIME	PARTICLE SIZE[1] % FINES 0 TIME	% CRUDE FAT AS IS 0 TIME	% FREE FATTY ACIDS 0 TIME	% FREE FATTY ACIDS 2 WKS	% FREE FATTY ACIDS 4 WKS	% FREE FATTY ACIDS 6 WKS	% FREE FATTY ACIDS 2 MOS	% FREE FATTY ACIDS 3 MOS	CATALASE INCHES OF FOAM 0 TIME 5-MIN	0 TIME 10-MIN	0 TIME 15-MIN	2 WEEKS 5-MIN	2 WEEKS 10-MIN	2 WEEKS 15-MIN	3 MONTHS 5-MIN	3 MONTHS 10-MIN	3 MONTHS 15-MIN
SRB-280-1	6.11	-	3.0	1.9	-	-	-	-	-	-	-	0.00	0.00	0.05	-	-	-	-	-	-
-2	-	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.05	-	-	-	-	-	-
-3	6.56	-	4.7	4.6	-	2.92	-	-	-	-	-	0.01	0.08	0.11	-	-	-	-	-	-
-4	-	-	-	-	-	-	-	-	-	-	-	0.00	0.05	0.08	-	-	-	-	-	-
SACK-1	-		-	-	-	-	3.06	3.41	4.90	5.25	5.82	-	-	-	0.00			0.05		
SACK-2	-		-	-	-	-	2.92	3.84	6.36	6.94	11.72	-	-	-	0.015			0.30		
SRB-275-1	6.54	-	3.7	2.8	-	-	-	-	-	-	-	0.03	0.06	0.11	-	-	-	-	-	-
-2	-	-	-	-	-	-	-	-	-	-	-	0.02	0.05	0.10	-	-	-	-	-	-
-3	6.12	-	4.3	3.7	-	3.11	-	-	-	-	-	0.03	0.07	0.10	-	-	-	-	-	-
-4	-	-	-	-	-	-	-	-	-	-	-	0.03	0.07	0.09	-	-	-	-	-	-
SACK-1	-		-	-	-	-	3.21	4.64	8.42	12.83	8.91	-	-	-	0.02			0.08		
SACK-2	-	-	-	-	-	-	3.11	4.85	8.62	17.56	13.84	-	-	-	0.25			0.40		
SRB-270-1	6.01	-	3.6	2.9	-	-	-	-	-	-	-	0.02	0.08	0.10	-	-	-	-	-	-
-2	-	-	-	-	-	-	-	-	-	-	-	0.02	0.07	0.10	-	-	-	-	-	-
-3	5.73	-	3.4	2.8	-	2.88	-	-	-	-	-	0.03	0.10	0.12	-	-	-	-	-	-
-4	-	-	-	-	-	-	-	-	-	-	-	0.02	0.08	0.10	-	-	-	-	-	-
SACK-1	-		-	-	-	-	2.98	5.08	8.61	13.10	17.04	-	-	-	0.04			0.90		
SACK-2	-		-	-	-	-	2.84	3.76	8.47	12.93	14.14	-	-	-	0.03			0.30		
SRB-265-1	5.87	-	5.1	4.9	-	-	-	-	-	-	-	0.05	0.10	0.15	-	-	-	-	-	-
-2	-	-	-	-	-	-	-	-	-	-	-	0.09	0.14	0.19	-	-	-	-	-	-
-3	6.68	-	4.4	3.7	12.06	2.92	-	-	-	-	-	0.07	0.13	0.20	-	-	-	-	-	-
-4	-	-	-	-	-	-	-	-	-	-	-	0.09	0.15	0.23	-	-	-	-	-	-
SACK-1	-		-	-	-	-	3.26	5.19	10.93	17.30	11.48	-	-	-	0.05			0.35		
SACK-2	-		-	-	-	-	4.04	5.35	11.68	19.95	9.39	-	-	-	0.06			0.25		
SRB-260-1	6.04	-	4.0	4.3	-	-	-	-	-	-	-	0.13	0.20	0.23	-	-	-	-	-	-
-2	-	-	-	-	-	-	-	-	-	-	-	0.12	0.21	0.30	-	-	-	-	-	-
-3	6.96	-	6.8	6.0	-	3.83	-	-	-	-	-	0.17	0.30	0.40	-	-	-	-	-	-
-4	-	-	-	-	-	-	-	-	-	-	-	0.19	0.26	0.40	-	-	-	-	-	-
SACK-1	-		-	-	-	-	4.21	8.25	14.80	24.25	13.64	-	-	-	0.12			0.15		
SACK-2	-		-	-	-	-	5.92	9.02	14.53	26.04	23.94	-	-	-	0.09			0.15		
SRB-255-1	6.22	-	6.1	5.2	-	-	-	-	-	-	-	0.15	0.30	0.41	-	-	-	-	-	-
-2	-	-	-	-	-	-	-	-	-	-	-	0.14	0.20	0.25	-	-	-	-	-	-
-3	6.44	-	5.2	5.1	-	4.31	-	-	-	-	-	0.13	0.25	0.37	-	-	-	-	-	-
-4	-	-	-	-	-	-	-	-	-	-	-	0.10	0.20	0.27	-	-	-	-	-	-
SACK-1	-		-	-	-	-	6.88	10.38	11.35	19.20	21.64	-	-	-	0.19			0.20		
SACK-2	-		-	-	-	-	5.87	9.51	13.73	24.70	29.31	-	-	-	0.10			0.30		
SRB-250-1	6.84	-	5.2	4.7	-	-	-	-	-	-	-	0.15	0.23	0.30	-	-	-	-	-	-
-2	-	-	-	-	-	-	-	-	-	-	-	0.20	0.31	0.40	-	-	-	-	-	-
-3	7.13	-	5.9	5.7	12.59	4.45	-	-	-	-	-	0.12	0.17	0.37	-	-	-	-	-	-
-4	-	-	-	-	-	-	-	-	-	-	-	0.10	0.16	0.23	-	-	-	-	-	-
SACK-1	-		-	-	-	-	5.52	7.06	11.48	20.57	28.40	-	-	-	0.15			0.80		
SACK-2	-	-	-	-	-	-	4.17	6.82	10.64	18.82	19.16	-	-	-	0.10			0.05		

1. INTERMEDIATES = MATERIAL THROUGH A 14 MESH SCREEN AND RETAINED ON A 20 MESH. FINES = THROUGH A 20 MESH SCREEN

2. MOISTURE CONTENTS OF TWO RAW RICE BRAN SAMPLES WERE: 10.52 and 10.75.

FIGURE 2. CATALASE FOAM TEST TO DETERMINE INACTIVATION OF ENZYMES IN RICE BRAN. TEST: 5 GRAMS OF PROCESSED RICE BRAN GROUND TO PASS 2.5/64 INCH SCREEN IS SLURRIED WITH 20 ML OF DISTILLED WATER AND THEN 2 ML 30% HYDROGEN PEROXIDE (H_2O_2) IS ADDED AND STIRRED IN. TUBE WAS 0.9 INCHES X 3.5 INCHES. READ INCHES OF FOAM AFTER 5, 10 AND 15 MINUTES. ACTIVE CATALASE ENZYME RELEASES OXYGEN FROM H_2O_2 CAUSING FOAM. A BLANK TUBE WITH 2 ML WATER IN PLACE OF H_2O_2 CAN BE RUN FOR COMPARISON. (NOTE: H_2O_2 BREAKS DOWN SLOWLY EVEN WITHOUT ACTIVE CATALASE CREATING A MINIMUM LEVEL OF FOAM). (NOTE: SAMPLES WERE COLLECTED AT END OF COOLER AND THUS HAD THE BENEFIT OF THE ADDITIONAL 2.5 MINUTES HOLDING AT 200 205 °F IN THE COVERED ELEVATOR CONVEYING EXTRUDED BRAN FROM THE BRADY TO THE COOLER.) FOUR SAMPLES WERE RUN IN THE FOAM TEST FOR EACH EXTRUSION TEMPERATURE.

CONCLUSIONS. IT APPEARS THAT STABILITY OF RICE BRAN PROCESSED BELOW 270 °F WILL BE INADEQUATE.



BEE 20x20 TO INCH

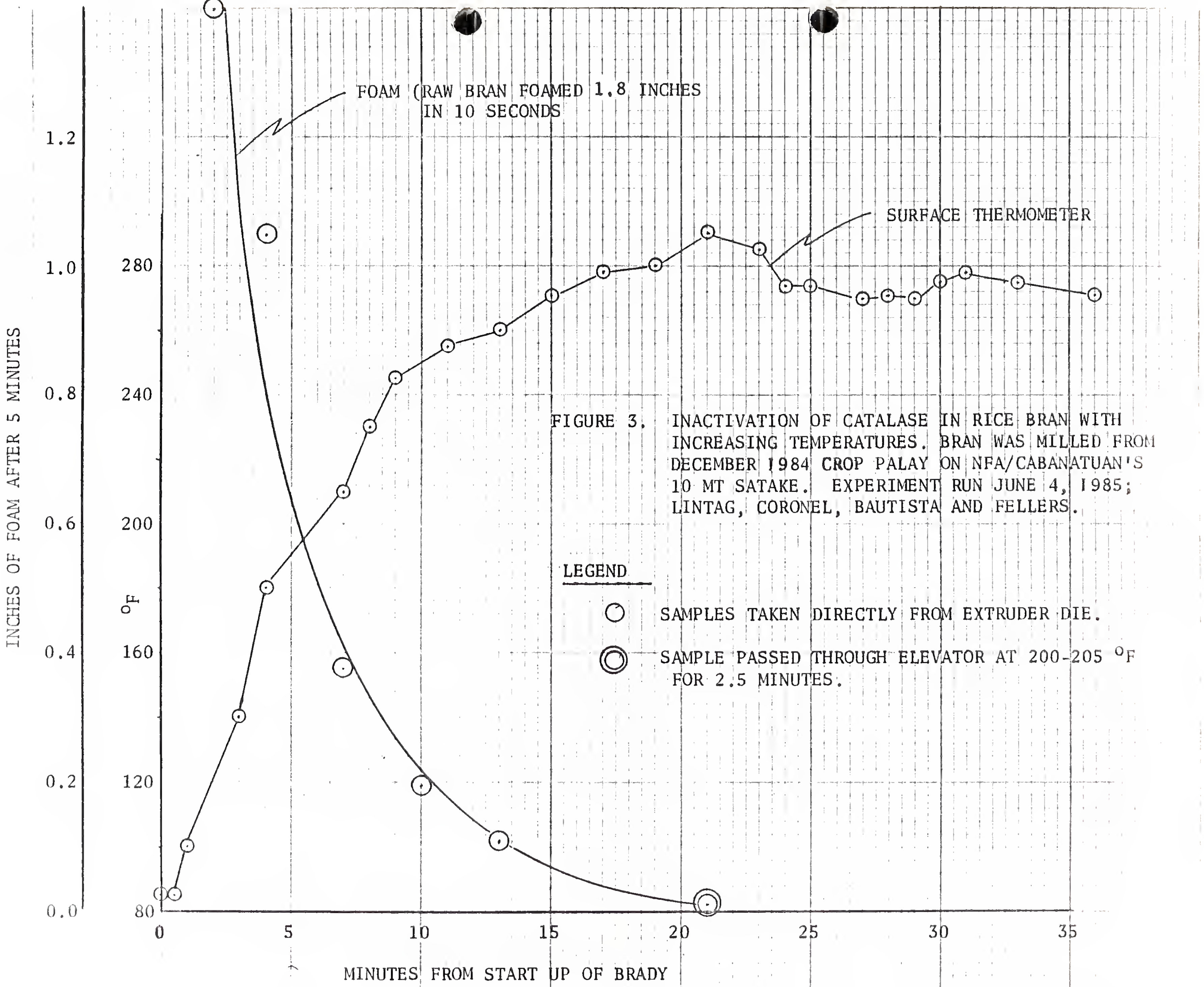
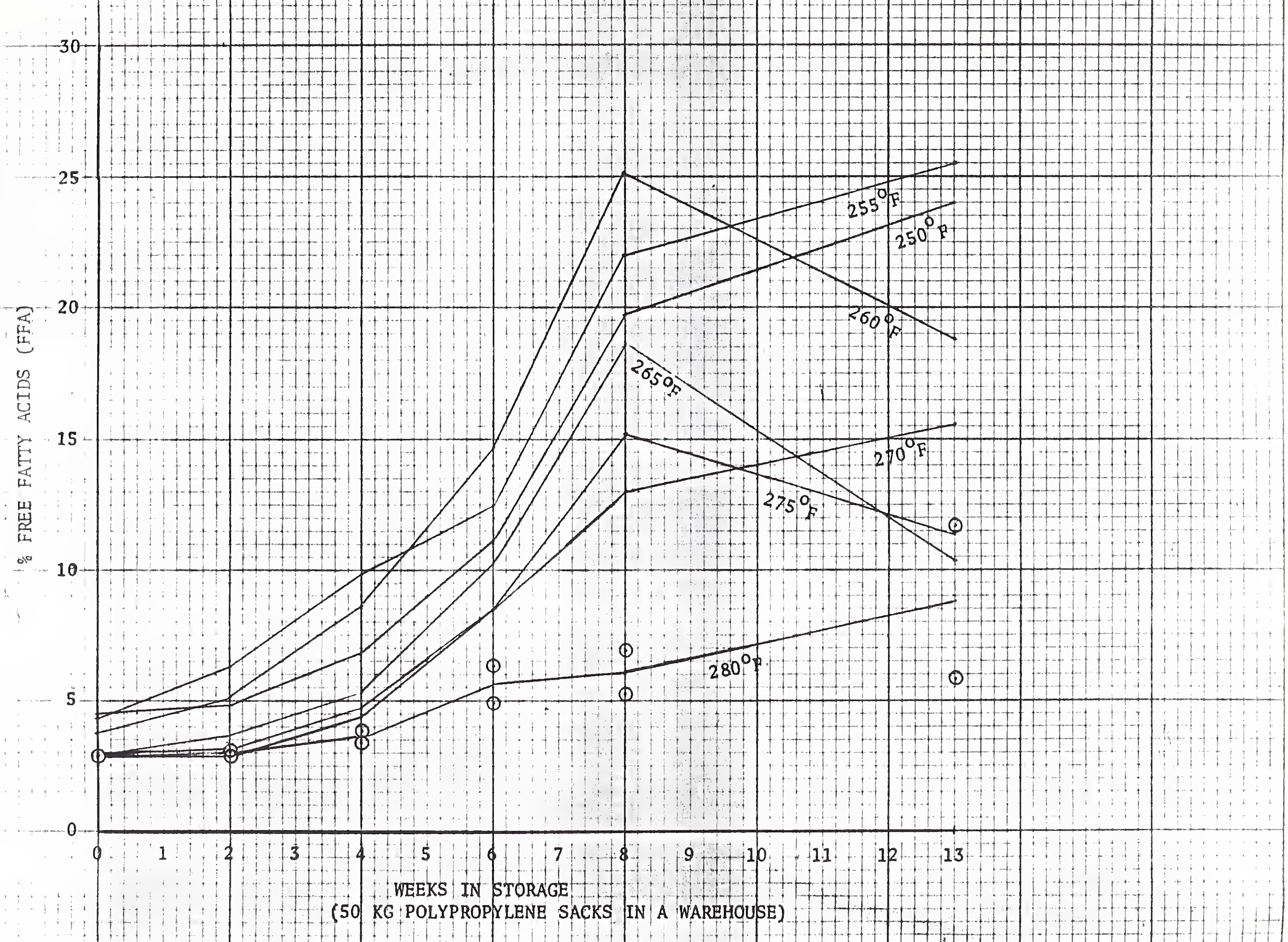


FIGURE 3. INACTIVATION OF CATALASE IN RICE BRAN WITH INCREASING TEMPERATURES. BRAN WAS MILLED FROM DECEMBER 1984 CROP PALAY ON NFA/CABANATUAN'S 10 MT SATAKE. EXPERIMENT RUN JUNE 4, 1985; LINTAG, CORONEL, BAUTISTA AND FELLERS.

STABILITY OF EXTRUDED RICE BRAN. CABANATUAN, THE PHILIPPINES.
(See Table for data)



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April 13, 1987

Dr. David A. Fellers
Nutrition & Agribusiness Group
Room 4300 Auditors Bldg.
Independence Ave. & 14th St., S.W.
Washington, D.C. 20250

Dear Dave:

We are pleased to see all the information stemming from the effort in the Philippines combined into one document. We feel that the effort put forth to complete this document will serve well in the future decisions about our rice bran project.

We have reviewed the report and have several comments for your consideration. Rather than commenting on all points, we have elected to comment on only the major points below and refer you to the attached report for other suggestions and changes.

Page 2- Rice Bran Supply. There may not be enough information available to make a statement on the improvement in the bran oil quantity that arises from sieving coarse fractions from the bran. You measured little improvement in the oil content of the bran after sieving; however, Tribelhorn measured a significant increase in the oil content (Ref. December 20, 1985) from 11.72 to 19.4%. In addition, the people at Farmers' Rice Coop. found that oil content could be moderately increased by sieving the bran prior to extrusion. This evidence, along with the experience of extruding the sieved bran in the Philippines, would indicate that the statement of a <u>slight</u> increase may be misleading.

Page 4- The first two complete sentences beginning "On 4/18/85 ......," are unclear. One specific problem is in identifying what period of time you were referring to when the rice bran was stabilized. This point requires clarification to insure that the point is made clearly.

Page 5- We agree that there is a possible link between the stability of the bran and the use of a belt drive for the Brady. Physical examination of the SRB revealed different thicknesses of the chips and, thus, a potential for nonuniform heat treatment. It may also be hypothesized that the instability of the bran can

be traced back to differential residence times in the extruder. Thin bran chips had higher FFA levels than did the thick chips. The evidence would support the fact that it is absolutely essential to maintain uniform chips coming out of the extruder.

Another reason for the instability of the bran may be traced to the storage conditions in the warehouse. The bran was highly infested and some of the instability of the bran could be attributed to the presence of insects in the bran. We might want to include this factor and indicate that more information is necessary to support either of these hypotheses.

Page 10- First Paragraph "A CENAPRO consultant.....": This statement is interesting and relates the potential impact of fines on extraction. It might be worth while to reference the source of this information and follow-up with any activity that NFA did with respect to this recommendation. As we recall, no action was taken by NFA concerning this recommendation, and, thus, we have no data to support this statement.

Table IV- In both Table III and IV, the defatted rice bran yield is indicated as 89%. This is too high if there is 12% oil in the bran. What is meant by the letters PA near the bottom of each table?

Page 11- You mentioned that 30% of the crude oil might be recovered as by-products. In recovering these materials, would not the cost of refining be reduced rather than increased, as you suggest, since these by-products have some value?

Fig. III- The refining process is outlined in this diagram. If one considers the minimum quality of oil necessary to have a marketable product, not all of the process steps might be necessary. Considerable savings might be realized by removing nonessential process steps. It may be necessary to explore the degree of refining necessary to achieve a marketable oil product.

Page 17- A definition of the extent of processing which is considered as "refining" should be made. As you know, there seems to be a substantial amount of confusion in the industry on what refining activity involves.

Page 19- Since the return on investment is tied so closely to the oil content of the bran and the value of the extracted bran, both areas where we have little information or field results, is it appropriate to state that the initial investment can never be

paid back? It may be more correct to say that given the factors, as they exist in the Philippines, pay back looks improbable.

Fig. IV- Again, the definition of refining is somewhat vague since you are suggesting a possible 65% yield of refined oil. Most processors of bran oil, including the Japanese, have experienced yields of approximately 50%. The use of 65% in the graph may not be realistic or achievable with the existing capabilities in any country, unless some lesser degree of refining is used.

Table IX- A premium paid for defatted rice bran is listed as a method that might improve the economics of the project. As we recall, the bran value in the Philippines is based on not only protein but also fat. Generally, hog feeders use the bran because it is the cheapest source of energy in the country. It may not be possible to recover a premium for the bran if the energy is removed with the oil.

It is not absolutely clear as to the direction the project should take. Certainly, the information presented in your document would indicate that the project is only in its beginning stages and that a lot more effort is required to obtain the data necessary to determine if the economics of rice oil production from SRB are good.

We believe that all remaining issues can be classified into three specific areas:

A. Problems identified but not answered.

1. Extruder Wear - Based on the effort to date, we do not have sufficient data to determine the cause for the excessive wear of the extruder. Distinguishing between the belt vs. direct drive would be useful but maybe a moot point since Brady no longer sells the unit with belt drive.

2. Bran Quality - This factor enters into the wear of the extruder as well as the quality and quantity of oil. We have collected data which gives us a limited amount of information on the quality, yet we do not have a sufficient amount to substantiate any conclusions. Bran quality is critical to both the economics and operations of the project and a definition of the minimum quality must be determined.

3. Processing Cost - We need a firm understanding of the cost to operate a stabilizing plant and the associated energy

requirements for the plant. We now have some limited experience on this point, yet our data is not accurate enough to reach any conclusions.

4. FFA Formation - Larger than expected increases in FFA were experienced after the bran was stabilized, which is contrary to the WRRC results. Since we have no reason to explain this change, examination of the long-term storage for bran in warehouse situations, such as those in the Philippines, should be done to answer this concern.

B. Unexplored questions

1. Bran Collection - We are unable to determine if collection of bran and delivery to a central process is feasible or if it should even be considered. The attempts made to collect bran during the operational phase of the project were limited, and, again, we do not have enough information to determine the feasibility of a bran collection strategy. Given the knowledge we have about the ability to collect bran efficiently, can we even consider this as a possibility in the Philippines?

2. Extraction and Refining - Our data base is the experience of NFA using raw rice bran to produce rice oil. We think that there will be differences in procedures when using the two different stocks. Thus, we know little of the requirements for the extraction and refining steps when using SRB.

This fact is important only in the event we are concerned about a finished or edible rice oil. It may be more realistic to consider only the sale of the bran or maybe crude oil and not address the technical issues of extracted and refined oil in the project.

3. Economics - You mentioned that the original economic analysis for rice oil production was in error because of the oil recovery percentages assumed. Should this analysis be redone prior to further exploration? The project direction may be affected by this analysis and the results measured to date.

4. Oil Content - Along with the economics comes the need to understand the minimum quantity of oil in the bran required to turn a profit. Is it possible to have sufficient oil in the bran to generate a profit? The Japanese seem to think so; however, the factor of stabilization has not been utilized extensively in their industry. If their margin of profit is low, the introduction of stabilization could reduce the profit to

zero or create a deficit. It might be worth while to understand the economics of Japanese rice oil production to clarify this point.

5. Oil Quality - Given the predicted problems with "refining" of the oil, we may wish to consider an alternative where the product is a partially refined oil. The major cost of the processing appears to be with the extraction and refining steps. If these can be avoided or minimized, the concept of stabilizing rice bran might be more attractive especially from the rice millers' standpoint.

6. Defatted Stabilized Rice Bran - DSRB has a value as a feed material for animals. The economics of the project are also dependent heavily on the value of this material. Information on the feed value of the bran obviously would be very helpful. Feed studies using this material have been limited, making it more difficult to determine the value of the material both in the Philippines and elsewhere.

C. Other Questions

1. Small Extruder - Based on the experience we had in the Philippines, which we admit is limited, it appears that the collection of the bran could be a major problem. Since Brady now has an extruder that is more in line with the needs of a small rice mill operator, would the economics of rice bran stabilization be more attractive using this machine since the raw bran would not have to be collected?

2. Extent of Proof - Is it necessary to prove that a suitable rice oil can be obtained from SRB. Maybe we would be better to prove that the bran can be stabilized and stored for sale to a refining company and let this portion of the project be done by others. Our bottom line would be the economics of the stabilization process and how it relates to the market value of the bran to refining companies.

3. Fallback - A fail safe position was built into the project should our original effort fail. This was the sale of the bran as animal feed rather than feed stock for the manufacture of edible oil. We might want to fall back on this position for the Philippines project.

4. Extruder Types - Given the number of extruders that have been used for stabilizing bran and the extent of their success, more information on these efforts to date and reasons for success or failure would be useful.

We have some internal issues with the project that still need to be addressed and probably cannot be resolved using other data bases. Since a significant time has elapsed since our project started, a number of efforts parallel to ours have begun from which data may be available. It would be foolish to proceed without examining the development of rice bran stabilization and the experience/data available from these groups. A possible sequence of determining our need to continue with project involvement in the Philippines might be as follows.

1. Economic Review - Re-examine the initial economics of rice oil recovery as presented by Enochian, et al., using all of the new data available to us. At a minimum, this effort would permit the identification of a more realistic picture based on the improved estimates. Perhaps this analysis would define a new direction for the project both in the Philippines and world wide.

2. Data Base Review - A determination of the state of the art for rice bran stabilization would be helpful. A specific protocol to effect this collection followed by on site collection of information in appropriately identified locations would make this information available. Another way of identifying this information would be through a small workshop or meeting directed at rice bran stabilization activity, data gathering and analysis.

3. Continuation of Project - Despite the amount of information that can be obtained in the effort outlined in number 2 above, we still have some questions that might need further investigation. Since we have the equipment available in the Philippines, we might answer some of the questions or problems considered in "A" above with a TDY in the Philippines where we would operate the plant to obtain added information for our data base. What we might specifically investigate is up for negotiation; however, answers might be obtained in a relatively short period of time. After we complete this task, we could turn the equipment over to NFA or another group. The main problem in this approach is the potential political problems which are currently present in the Philippines!

Alternatively, a number of these questions might be resolved using equipment in California. We do have a better set of circumstances in the U.S. to control conditions and test hypotheses. We could create any situation we require in this setting and be sure our results would be completed. We might consider WRRC in this effort as a cooperating group for analysis and data interpretation.

We hope the above comments are useful and that they will help to clarify the points you discussed. We look forward to meeting soon to discuss this document and the project in total.

Sincerely,

Ron Tribelhorn

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Research Associate

RET:il

Enclosure

CC: J. M. Harper

Response to 4/13/87 Comments by CSU on
"Status - Rice Bran Stabilization: Part I, The Philippines".

Letter Reference	
page 1, Par 1:	The document has been completed, that is, sections relating to status worldwide have been added. The document will not be reworked but filed along with CSU comments and a copy of this response.
Page 1, (page 2)	Less weight was given to CSU results (Dec. 20 1985) because they did not include a measure of both the fines and coarse fractions and because the results seem unreasonable. To go from 11.7% fat in the rice bran to 18.0 to 19.4% in the fines fraction means that one would need to remove 35 to 40% of a coarse fraction with no fat at all! The improvement in fat content and reason for same at Farmers' Rice Cooperative, W Sacramento, CA is not known. Several factors may have contributed to this "moderate" increase including repair of mill screens, scalping, reduced pressure of milling, selection of rice bran streams and etc. Accordingly, my best guess is for a "slight" (approx. 1%) improvement in fat content. However, this is likely to be highly dependent on the milling system. If disc huskers are used by NFA, then most of the germ will be removed in dehulling and thrown out with the hulls. If rubber rolls are used, the germs are likely to be in the bran and if the bran is scalped, these high fat (30%) particles will be removed with the broken rice reducing the shift in fat content desired. Germ particles are typically separated by scalping rice bran on a system of screens composed of a 1,500 and an 800 micron screens. Rice bran passes through the 800, germ is retained on the 800, and brokens are retained on the 1,500. Since germ represents 2 to 3% of paddy, it is a significant part of bran when rubber roll hullers are used but less so when disc huskers are used. If low fat content of bran is primarily due to significant dilution by rice flour (starch) which comes from broken, chalky, and immature kernels and to heavy milling pressure (pushing capacity), then scalping will probably have only a minimal effect on shifting fat content.
Page 1, (page4)	Rewrite of sentence to clarify meaning. "On 4/18/85, having recognized the stability problem at 250°F, the extrusion temperature was raised to 270°F in an attempt to improve stability. However, this SRB proved to be unstable as well, thus all 92 MT of SRB made during the start-up operations from 2/12/85 through 5/31/85 was unsuitable for extraction for recovery of edible oil."
Page 1 & 2, (page 5)	Literature does not suggest that insects per se cause FFA's but, rather, insects lead to damp spots where molds can grow and release lipolytic enzymes that cause increases in FFA's.
Page 2, (page10)	The reference to "CENAPRO consultant" is from the trip report by George Kopas, March 12-23, 1984, page 6. The CENAPRO consultant was Mr. Cabahug and a copy of his report is attached to Kopas' trip report. Other information corroborates the problems created by "fines" in extraction and refining.

ge 2, (Table IV) Both Table III and IV are direct extracts of NFA data Tables. Admittedly, 89% yield of defatted rice bran from raw rice bran is too high. On can easily see how NFA calculated it: 11% oil extracted leaves 89% defatted bran.

Page 2, (page 11) I was assuming that CENAPRO and RICOR actually did recover gums, acidulated oil and stearine and probably sold it for feed or soap. Under these conditions, NFA's refining cost was the 6,000 pesos/MT refined oil plus the value of the by-products. If CENAPRO and RICOR actually discarded these products (I find it hard to believe) without obtaining any value, then their recovery and sale in later refining runs should reduce the 6,000 peso/MT of refined oil cost.

Page 2, (Fig III) NFA Tacurong oil was fully refined and quality was considered poor. I don'T believe we can compete with soy, corn or other polyunsaturates except with a completely refined rice bran oil. The one exception might be where a large industrial user buys all the oil for a specific application, e.g., industrial frying oil may not have to be dewaxed nor heavily bleached.

Page 2, (page 17) While we can, and others have, defined "refining", we are still saddled with the "loose" use of the word in the trade and literature. Technically, I believe processors use the word to mean removal of FFA's---e.g alkali refining; or physical refining (removal of FFA's under vacuum and heat.

Page 2, (page 19) The assumptions for this financial performance analysis are given. Under these conditions, the process is not profitable. Section I. H. 2. discusses how changing the assumptions can affect profitability.

Page 3, (Fig IV) Agreed that the definition of "refining" is vague. In this case, I mean yield of edible oil from crude as extracted and before degumming.

Page 3, (Table IX) On the other hand, NFA receives a 10 to 15% premium for defatted bran at Tacurong. Also, it could be stored and sold in the off-milling season when prices are higher, e.g. see "Status in Indonesia".

Comment on text p. 18 Yes there is a credit given for defatted bran; see Annex I. No credit has been given for gums, acidulated oil or wax/stearine. According to CENAPRO and RICOR, they don't recover them.